GREAT EXPLOITS IN THE AIR

BLACKIE & SON LIMITED
50 Old Bailey, LONDON
17 Stanhope Street, GLASGOW

BLACKIE & SON (INDIA) LIMITED
Warwick House, Fort Street, BOMBAY

BLACKIE & SON (CANADA) LIMITED
TORONTO

E 528

LIEUT. BYRNE QUALIFIES FOR THE CATERPILLAR CLUB

• From the drawing by C. Fleming Williams

Frontispiece

GREAT EXPLOITS IN THE AIR

BY

F. V. MONK

AND

H. T. WINTER

Member of the Royal Aeronautical Societ

With Eight Half-tone Plates
Text Maps and Diagrams

BLACKIE & SON LIMITE

The Enterprise Library

The Mastery of the Sea. Cyril Field.
Electricity as a Wizard. Charles R. Gibson.
Seven Ages of Invention. Cyril Hall.
The Wonders of Transport. Cyril Hall.
Triumphs of Invention. Cyril Hall.
Conquests of Engineering. Cyril Hall.
Wood, and what we make of it. Cyril Hall.
Treasures of the Earth. Cyril Hall.
Conquests of the Sea. Cyril Hall.

Printed in Great Britain by Blackie & Son, Ltd., Glasgow

Acknowledgments

Of the many authorities consulted the authors desire to acknowledge the extensive use they have made of those three authoritative works: *The Story of a North Sea Air Station*, by C. F. Snowden Gamble; *The German Air Raids on Great Britain*, by Captain J. Morris; and *The Great Pacific Flight*, by Air-Commodore Sir C. E. Kingsford-Smith and C. T. P. Ulm.

Their thanks are tendered to Air-Commodore Sir C. E. Kingsford-Smith for permission to use the illustrations for the Pacific Flight section; to Charles Dixon (author of *The Conquest of the Atlantic*) for his valuable assistance with The Caterpillar Club section; to the Curator of the Imperial War Museum, South Kensington, for the three illustrations for "Modern Knights" section; to *Flight* and to Fokker & Co. for illustrations facing pages 168 and 192; and to the Editor of *Pearson's Magazine* for permission to use "The Exploits of the Caterpillar Club" and "The Exploration of the Upper Air".

The authors are indebted also to the following works:

The Dover Patrol, by Rear-Admiral Sir Reginald Bacon; *The Defence of London*, by Commander A. Rawlinson, R.N.V.R.; *The War in the Air*, by Sir Walter Raleigh; *R.F.C. H.Q.* 1914–1918, by Maurice Baring; Articles in *The Times*, *Daily Telegraph*, and *Flight*; *The German Air Force in the Great War*, by Major G. P. Neumann; *Aero Engines*, by G. A. Burls; The *Journal of the Royal Aeronautical Society*; *All the World's Aircraft*, by C. G. Grey.

Contents

PART I

PART II

PART III

PART IV

PART V

PART VI

List of Illustrations

MAPS

GREAT EXPLOITS IN THE AIR

PART I

Modern Knights

"Telling old battles over without hate."

KIPLING.

The Menace

In August, 1914, a resolute foe was gathered in force but a few miles across the water. That foe was Germany, who had planted both feet firmly on the Belgian coast, and was now eagerly and fiercely gazing across at England.

But those few miles of sea, patrolled by the British navy, made an impassable barrier. By what other way was England to be reached?

There were the vast spaces of the air. Under cover of night, what havoc could not be wrought! Camps could be raided, harbours fired, ships destroyed, arsenals blown up—yes, London itself could be attacked and grievously wounded.

Already the enemy had between two hundred and three hundred sea- and land-planes, and some twenty rigid and non-rigid airships, either in use or under construction.

The seaplane could carry its pilot, a passenger, and fuel and stores for a four hours' flight; could travel at least 62 miles an hour, alight on the open sea with the wind blowing at 25 miles an hour, remain thus for an hour with the engine off, and then fly away again. It was so fitted that it could be lifted off the sea and placed on board ship.

The Zeppelins had platforms for machine-guns, one in each car, and two on the top of the envelope, and carried bombs weighing 600 lb. charged with tri-nitro-toluene and steel bullets.

Of the enemy's airmen it was well known that they were skilful, dashing, brave.

How long before this formidable force would attempt to strike terror into the hearts of our people?

There was not a minute to be lost. All who had any knowledge of flying rushed to offer themselves, and were enrolled in the Air Services. Besides those, elderly men and young men, youths who had but just left school, and boys who were still at school hurried to the Air Stations, their spirits aflame to join the

battle against the enemy whenever he should come.

What work there was to be done! All the East Coast must be patrolled from Kinnaird Head in Scotland to Dungeness in Kent: there were machines to be made, pilots to be trained, mechanics to be found, arms and ammunition to be manufactured.

Our spirit was as fine and resolute as the enemy's; but was our aircraft the equal of theirs?

Our engines were not so reliable, our craft nothing like so well armed, their structure not suited for the quick manœuvre of battle, and they were inferior in wireless equipment.

We had only seventy-seven machines for defence—forty aeroplanes, thirty-one seaplanes, and seven airships—and a great stretch of coast-line to guard.

Only two of those aeroplanes and one airship were armed with machine-guns. The rest had but the ·45-inch rifle with incendiary bullets, many of which were ineffective, and the ordinary ball ammunition.

A small number of grenades was issued consisting of a steel container charged with trinitro-toluene and fixed to a steel rod, which fitted closely the barrel of the ·303-inch Service rifle. This grenade was loaded by the muzzle,

and was fired by means of a blank cartridge, but its range was only about 300 yards.

As for bombs, there were a few 20-lb. Marten Hale, and a few 100 pounders, but as their safety devices were of poor design, they often proved more dangerous to the user than to the enemy. In a few days, however, a new bomb in small quantities was available, filled with petrol and fitted with a detonator for firing the petrol.

Seaplane stations were established at Calshot, Dundee, Eastchurch, Felixstowe, Fort Grange, Isle of Grain, Killingholme, and Great Yarmouth, and day by day the long coast-line was patrolled, and at night the vigilance of the defenders was not diminished.

There were the "Dawn", "Midday", and "Sunset" patrols, but the enemy did not come —not yet.

The reports for many a day read much the same as this one:

Report on Seaplane No. 142

Wind—E—10 m.p.h. Weather hazy.

4.30 p.m. Left Yarmouth.

4.31 p.m. Passed a T.B.D. and signalled her.

4.35 p.m. Passed Cross Sands Light Vessel—1000 feet.

4.40 p.m. Passed H.M.S. *Spanker* and reported by W/T.

4.55 p.m. Descended at Smith's Knoll Light Vessel and tied up astern
Asked for information as to enemy ships. (Nothing.)

5.0 p.m. Ascended and steered North 10 miles at 600 feet.

5.10 p.m. Laid course for Newarp Light Vessel.

5.20 p.m. Passed Newarp, laid course for Yarmouth—800 feet.

5.35 p.m. Arrived Yarmouth. Nothing to report.

At Grips

And then one day they came.

How quickly they revealed the weakness of our defences and the ineffectiveness of our machines! Our pilots could not reach their heights, and even if they had, they would have been helpless, for their planes were so poorly armed. Many of them, indeed, had only a rifle, and in those early days our ardent and courageous defenders had determined to ram any airship that could be reached, which would have meant their certain death.

In the enshrouding blackness the enemy's airships came gliding over the sea at a great height, reached the silver line of England's shores, and then proceeded to spill death like an avenging hand, out of the black caverns of the night.

At first they came singly or in pairs, stayed but for a few minutes, dropped only a few bombs, and sped back over the seas. Night after night our airmen went up after them, but could not find them. It was so easy for those airships to hide completely in a bank of fog or behind a curtain of mist, or rise rapidly to such heights that they could not be followed, or change their direction and be lost in the darkness. Time after time the enemy was reported flying across, and a vague direction was given, but though our airmen went up immediately and searched for them, sometimes for over two hours at a stretch, they did not see them at all, and returned impatient and exasperated, feeling themselves beaten and inferior.

The landings after these fruitless night chases were exceedingly dangerous. One Flight-Lieutenant had been flying for over an hour trying to find the approaching airships, when his engine suddenly stopped. He was in a precarious position. The night was so dark that he could see nothing but blackness beneath

him, and there were bombs aboard. If he hit a tree or came down to earth heavily, he and the plane would be blown to fragments. His altimeter showed him that he was down to 100 feet. He must act now or it would be too late. Still holding the controls, he crawled out on the port wing, held the machine down, counted six and—jumped. He was only slightly shaken, and the machine scarcely injured.

Then, the method of carrying bombs added enormously to the risks of our airmen. One, after a two hours' patrol in search of the enemy, misjudged his height, came down heavily, and was blown to pieces by his exploding bombs.

These were truly stirring times for England —days of great anxiety, and nights of heroism and of dread, when there would be the hurried warning of the coming of an invisible foe, then the hiss of great bombs, and ear-shattering explosions, and screaming, and the barking of dogs, and shouting, and orders sharply given, and then red flames leaping up, and then silence.

It was so dreadful to be helpless. If you could have found the foe and fought him, the horror would have been halved.

But do not imagine that John Bull was lying down with arms wrapped closely and frantically about his head, as the German papers had drawn him. Anything but that.

A hundred great adventures were planned. Whilst workshops and factories were ahum night and day, turning out machines, ammunition, arms, searchlights, all the engines of war, daring spirits—and they were numberless—sought and found the enemy in their own strongholds.

It was no good waiting for them to come; why not then go out to meet them, go right to their starting-points and beat them back?

Vessels were fitted up as seaplane carriers, a seaplane was put aboard, and the vessels took up stations at various points along the Belgian coast, and even right in enemy waters.

The German airships generally set off before dark. If fast seaplanes therefore were lying waiting, the pilots would have a great chance of spotting them in the half light and bringing them down. If they failed in this, there was the hope of catching them as they returned in the dawn.

Four of these seaplane-carrying vessels, day after day, as twilight was falling, took up their positions at the different points in the North Sea. On almost every calm night the seaplanes were sent off, and searched the air, and still the enemy eluded them. The Captain of one of these four boats, the *Kingfisher*, with complete disregard of danger, would take his trawler, armed with only one 12-pounder gun, right

into the enemy's water, beyond the Haaks lightship, and there wait patiently for sight or sound of the hostile craft, and always he was disappointed. Even when the sound of the engines came to him and gun-fire was opened upon the enemy, cloud or sea-mist would suddenly envelop him and make easy his escape.

But greater success had attended our efforts elsewhere. The enemy had built huge sheds at their air-bases in Belgium to house their airships. One night Lieut. L. G. Hawker, R.F.C., with a goodly supply of bombs, flew off in his B.E.2C. and made for the German station at Gontrode. He was not challenged till he was almost over the sheds. Calmly he circled over them and calmly he dropped bomb after bomb. Then when flames burst forth beneath and satisfied him he had severely damaged the sheds and any aircraft within, he hastened away back over the sea to England.

Many such attacks were made, and to such great purpose that in a few weeks the enemy found the place too warm for him, and abandoned the station, taking the airships back to their own frontier.

Before this an important raid had been made right into the German's strong naval base at Cuxhaven, and though no damage had been

inflicted, most valuable information regarding the plan of the place had been gained.

Gradually our defences were improving. Better aeroplanes were being turned out with more powerful engines, and designed for fighting; anti-aircraft guns (with searchlights to operate with them) were placed at many points along the coast; there were machine-guns and searchlights mounted on motor-cars, which could be rushed to any locality if the enemy craft eluded the fixed guns; and machine-guns and greatly improved bombs were added to the armaments of many of our aeroplanes.

How a Great Raid was Broken Up

One night, 6th June, 1915, to be exact, the enemy had planned to make a great raid. The airships L.9, L.Z.37, L.Z.38, and L.Z.39, heavily armed with deadly bombs, set off at dusk, their commanders determined to work havoc up and down the English coast. They little knew what was in store for them. There were seaplanes waiting for them along the Belgian coast, and would be still waiting for them on their return: they had to evade maybe twenty, maybe thirty of our aeroplanes along the east coast, and they had to run the gauntlet of our anti-aircraft guns that were now positioned at various points.

Moreover, their departure had been signalled, and a warm reception was being prepared.

Trouble came soon to them. The L.Z.38 had not travelled far when she was sent down again by engine trouble, and could take no part in the raid. The L.Z.37 and L.Z.39 got away well, passed safely through the first danger zone of our seaplanes, and then ran into a blinding fog. They moved onward, blind, groping their way as it were, through the enshrouding blackness. They ascended to try to get above the fog bank, and still they were sightless, with but their instruments to give them vague bearings. Deciding it was useless to attempt to break through to clear air, just before midnight they turned back for home.

Now, an English pilot, Flight-Sub-Lieut. R. A. J. Warneford in his Morane "Parasol" monoplane, just *after* midnight was speeding away with a goodly supply of bombs which he intended, if not brought down, to drop on the German airship sheds at Berchem Ste Agathe. Suddenly, over Ostende he saw above him an enemy airship, no other than the L.Z.37. His heart gave a bound, and every nerve in his body tingled with the excitement of the coming fight. Here was an opportunity! He or the enemy should go down this time. Into a steep climb

he sent his plane. What would the enemy do, try to get higher still, or fly on and open machine-gun fire on him as soon as he came in range? Up and up he climbed, faster than the airship. There was a crackle of its machine-guns. Was it imagination or did he feel the bullets whizzing by him? A hit on his petrol tank and that would be the end. In a wide curving climb he got the position he wanted, above the enemy, and released his bombs. His aim was true: there was an explosion that seemed to tear the night to shreds, a flame shot up from the L.Z.37, and she rushed to earth cutting a blood-red, fiery path through the blackness of the night. Doubtless the crew were burnt to death before they hit the ground. Warneford had won, but so great was the rush of air caused by the explosion and the burning, that his craft was driven and rocked like a feather in the wind. He lost control and was forced into enemy country! Here was a predicament. The whole locality would be warned of an enemy by the great blaze of the airship, and the chances of escape were anything but bright. He discovered too a broken petrol pipe. Picture him, then, working feverishly there in the night, expecting every minute to hear the engine of an avenging plane, or an enemy voice challenging him out of the darkness.

But Fortune was with him this night, though, alas, she turned her face away only ten days later. He repaired the damage, got away again, dodged the enemy, and returned safely to his aerodrome. A great honour came to him and then death. The King conferred upon him that most coveted badge of bravery—the V.C.—and then, whilst flying a few days later at Buc, near Paris, he crashed and was killed.

Whilst Warneford had been fighting the L.Z.37, two pilots of the Royal Naval Air Service, Flight-Lieut. J. P. Wilson and Flight-Sub-Lieut. J. S. Mills, had paid a visit to Evère, near Brussels, dropped bombs on the airship sheds there and destroyed the L.Z.38, which you remember had put back with engine trouble only a few hours before. How did they know the L.Z.38 was back in her shed? Well, it was wonderful how news of the enemy's movements came to us. The long ears and keen eyes of our Intelligence Service generally managed to pick up what escaped the vigilance of submarine and seaplane and aeroplane, ever on the lookout for suspicious enemy movement.

Kapitän-Leutnant Mathy

So, two valuable airships had been destroyed

and one driven back, but the fourth, the L.9, had a different tale to tell.

She was commanded by that formidable and skilful airman Kapitän-Leutnant Mathy, who had already wounded England in a previous raid, but this night he made his landfall [1] at Cromer, turned northward, flew up the coast over Lincolnshire and as far as Flamborough Head. Several of our pilots went up after him, but either because of his great height or the mistiness of the night, failed to find him. At Flamborough he turned round and came back over Hull.

Although he well knew the danger he was running—the horror of such a death as overtook the crew of the L.Z.37—he circled over Hull for twenty minutes, so cleverly hiding his craft in the mist banks and changing his altitude and direction that though the guns of the H.M.S. *Adventure*, which was lying in the harbour, fired round after round at him, he passed untouched over the coast and out to sea.

A large number of bombs had been dropped. Twenty-four people were killed and over fifty wounded, whilst many buildings were badly damaged.

[1] *Landfall:* that is, a recognizable mark visible as far as possible seawards to ships approaching land.

The Enemy Strikes Heavily

Those were dread nights in England. To be attacked thus by an invisible foe somewhere up in the clouds; to have the quietness suddenly shattered by an explosion, the mere noise of which hit upon the brain and knocked men flat upon the ground; to see great pieces of masonry hurtling through the air, and walls tottering and crumbling; to be stunned by crash after crash, to see flames spurt up—and to feel that the next bomb perhaps would blow you to pieces! Was it any wonder that whole families in Hull and other places on the east coast left their homes as evening fell and slept in the open fields? Was it any wonder that people, hearing the warning, rushed with their children down to the cellars, to the underground passages, to shelters hastily dug out in their gardens?

Orders were issued that all lights, even to the smallest candle, were to be extinguished the moment an "Air-raid Warning" was given.

So strictly was this order enforced, that to strike a match anywhere near the sea-front was looked upon as the work of a traitor and a spy, and the offender was indeed likely to be treated as one.

At the sound of the warning siren then,

eastern England hurriedly slipped on its sable robe.

What bravery was crowded into those frightful days—bravery of friend and foe alike! That was the pity of it all—that by some mad, cruel power all the heroism of great nations was called forth to inflict and to endure suffering and death.

As the summer of 1915 progressed, more and more, and fiercer and fiercer became the enemy raids. Fleets of airships now flew over the land, leaving death and destruction in their wake.

On 9th August eleven of the enemy passed over the coast led by Korvetten-Kapitän Strasser, a commander of great daring and skill.

Rain, which weighed down the airships, defeated this raid, but over eighty bombs were dropped which killed seventeen people and injured twenty-one.

Four nights later, six more people were killed and thirty-four injured. Next, Leyton, Leytonstone, Wanstead Flats, and Chelmsford were heavily bombed, and the Leyton railway station badly damaged. Then East Suffolk and London were raided and eighteen people killed, another thirty-eight injured, and damage done to the extent of £20,000. The next attack was upon

Skinningrove, where there was a large and important explosives factory. Many bombs were dropped, and the factory escaped destruction by a miracle, for one bomb came through the roof and actually pitched right upon the cover of a vessel full of that high explosive tri-nitro-toluene, but failed to explode. That same night the famous Commander Mathy came again, penetrated to London, and dropped high-explosive and incendiary bombs which killed and injured a great number of people and wrought damage of nearly £1,000,000.

A fearful night was that, when, for how long?—it seemed ages—shattering explosion succeeded explosion, sheets of plate-glass from the spacious fronts of great city firms were blown to fragments, huge pieces of granite were tumbled into the road, roofs and walls came crashing down, and the angry glare of great fires lit up the sky. The din of bursting bombs and falling buildings, the bark of our anti-aircraft guns, the shrieks of women, the groans of the dying, the clang of the fire-engine bells—these and a hundred other sounds combined to make the night hideous.

Dozens of pilots went up from their stations, flew at 5000 feet, 7000 feet, 10,000 feet, and still could not sight the enemy. Others went up on the coast to cut off his retreat and flew

in the darkness hour after hour; anti-aircraft guns at several points blazed away at him; and our seaplanes waited for him to pass back over the sea—but Commander Mathy bore a charmed life and escaped them all!

To what was due this failure to beat off the enemy? First and foremost, bad "ground" organization. Our landing-places, that is, were not sufficient, nor were they suitably placed, so that the pilots were kept within certain bounds, beyond which they dared not go without risking almost certain death and the destruction of their machines by crashing on unknown and unprepared ground. Added to this was the great superiority of the Zeppelin airship, whose speed was 60 miles an hour and its "ceiling" (i.e. its maximum altitude) 13,000 feet. The speed of our fastest machines certainly was 72 miles per hour, but their ceiling was only 10,000 feet, and when fully equipped for battle took forty-five minutes to climb to that height. Moreover, the Zeppelin, if threatened by gun-fire or enemy plane, could rise rapidly, far more rapidly than our planes could follow, out of the danger zone.

Then it must be remembered that the Zeppelins came on the darkest of nights, and although the sound of their engines and propellers could be plainly heard, and perhaps their dim out-

line seen with the naked eye against the stars and the light background of clouds, as soon as our pilots were in the air the din of their own engines drowned all else, and it proved for the most part impossible to sight the enemy.

Could searchlights have caught the raiding airships in their beams another tale would have been told, but as yet, although London was ringed with searchlights, there were not more than half a dozen along a one hundred and fifty miles of coastline, so that the enemy could pass over freely at almost any point.

Once, which shows how difficult it was to spot a Zeppelin, one of our pilots up on patrol duty had an enemy airship under him, and whilst the watchers on the ground could plainly see the ship gliding along, the pilot was quite unaware that it was anywhere near him.

The enemy had hoped by their raids to destroy British morale—in other words to frighten us into giving up the fight.

How mightily mistaken they were, for instead they only strengthened us in our determination to win through! No part of the nation wavered.

The women of England had faith in their men, and our men had faith in themselves.

Let us go to the enemy records to get a picture of events at this time.

Here is a diary of the German Air Station at Borkum, and from it will be gathered a good idea of our many activities:

1915.

19.1. Battle-cruiser of the *Lion* class reported in 100 B.

30.1. Bombed submarine in 089 E, the same in 117 E.

11.4. Sighted enemy submarine.

11.4. Dropped bombs on submarine, which dived quickly. Result doubtful.

26.4. Found place of English mine-field in 081 E.

28.4. In 098 E bombed enemy submarine. Dropped bombs on submarine without result. English seaplane over the Ems. A bombing attack on Borkum Hangars was repelled by machine-gun fire from the Station. The return was cut off by own aircraft. The English machine flew over Dutch territory, broke out to sea at Schiermonikoog, and was fired at by English seaplane with rifles. Pursuit abandoned owing to superior speed of the adversary.

5.7. Dropped bombs on enemy submarine.

9.8. In 034 E sighted five enemy cruisers, dropped five bombs, effect not observed, enemy opened fire with shrapnel.

Do you observe the many references to our submarines, and that they were operating right in the enemy's waters of Heligoland Bight?

Whilst our fighting forces were thus employed all Britain was a factory, working day and night to turn out machines and ammunition. Machine-guns and mountings were added to practically all our aircraft; small single-seater battle-planes of high speed and rate of climb, and fitted with a machine-gun that could fire through the rotating airscrew, were being turned out in scores; wireless equipment was increased tenfold. The number of single-seater planes had increased from thirty to three hundred and ninety-one; two-seaters from one hundred and seven to two thousand and three; seaplanes from fifty-two to two hundred and sixty-two. As for engines, their number had risen from one hundred and thirty-eight to two thousand six hundred and thirty-two.

Stirring Times

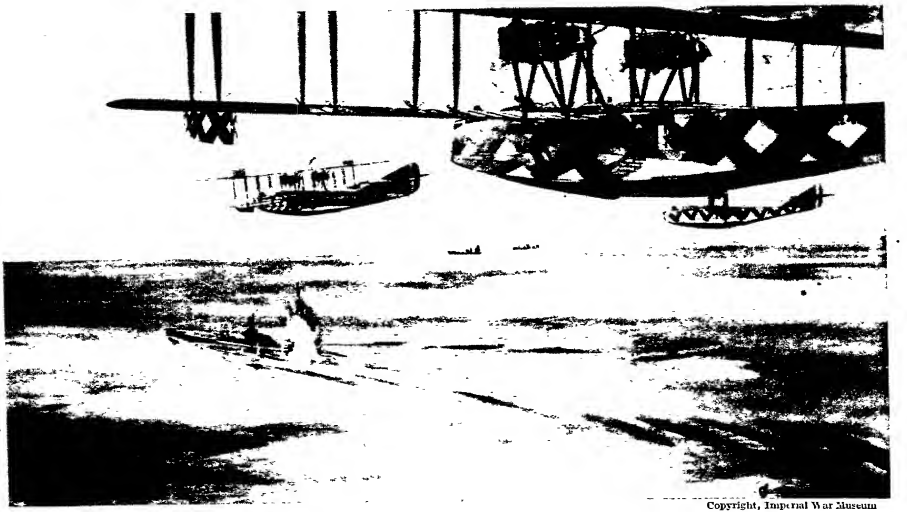
A great raid was made by the enemy on the pitch-black night of 31st January, 1916. Nine airships came over in relays and flew, some for hours, over England. Four hundred bombs were dropped, killing seventy people and

wounding one hundred and thirteen, and doing a great amount of damage.

When the warning of their coming was given, pilots jumped into their cars and dashed off to the aeroplane sheds with the mechanics following in lorries. Out came the planes, their engines were tested, and then with a roar up they went into the inky darkness and raced backwards and forwards along the coast. Then came the rain and mist, blinding the pilots and sending them out of their course. They flew on, they climbed to get out of the storm, but all to no purpose. The storm and mist and blackness of the night wrapped them round and drove them down.

Speak to any of those pilots and they will all tell you of the fearsomeness of those night flights after an enemy they could neither see nor hear. They will tell you too of the loneliness—the utter loneliness of flying thus single-handed and with but a black bank before you into which you seem to be for ever diving.

Two flying officers were killed that night—they crashed on landing in the darkness. So once again the enemy got away, but one ship, the L.19, which had been cruising over England for eleven hours, ran short of petrol. As she drifted helplessly over Holland, the Dutch fired upon and hit her, so that she drifted in



E 528

"HIT": A PATROL OF F.2A FLYING-BOATS BOMBING A GERMAN SUBMARINE

From the painting by C. Fleming Williams

Facing p. 32

the wind westward and came down off Spurn Head. The commander hailed H.M. trawler *King Stephen*, which was patrolling there, and asked to be taken on board, but this the skipper refused, for the crew of the airship numbered more than his, and he was fearful that his vessel would be seized. Although money was offered by the German commander, the *King Stephen* put about and ran to the Humber to report.

Nothing more was seen of the L.19, but a bottle was picked up some days later, containing this note, written by the Commander and addressed to the Raid-Commander, Korvetten-Kapitän Strasser:

"With fifteen men on the upper platform of the L.19 drifting in the North Sea. Had trouble with three engines and head-winds, consequently delay until ran into fog, and drifted over Holland. We were fired at considerably; ship was hit and became heavy with the engines failing definitely. The 2nd February about noon will probably be our last hour."

The handwriting was firm. No crying out, no word of fear, you see. A brave man, this commander of L.19.

Still more stirring days were now to follow. Enemy aeroplanes joined in the aerial attacks on England, and two came over and bombed

Lowestoft and Walmer. Five naval Zeppelins raided our eastern counties, and not a plane left several of our air-stations that night, for they were not warned of the coming of the enemy. There was a mystery here that was never satisfactorily cleared up. All the telephone and telegraph wires at these stations had been cut, it was thought by spies. Soon it was reported that the German High Seas Fleet showed signs of movement, then that a strong force of cruisers, supported by the battle fleet, was on its way across the North Sea to our east coast. Admiral Beatty steamed south to cut them off, and Commodore Tyrwhitt, with the Harwich force, at once put to sea.

The whole enemy fleet, with a strong force of airships, was coming fast towards our shores. The night was very dark, and though numbers of our pilots went up, none was able to engage any of the six Zeppelins that crossed the coast.

At dawn of the 25th April the enemy's ships came into view and opened fire on Lowestoft and Great Yarmouth, whilst the airship L.13 directed their range. As soon as this hostile craft was spotted, several of our pilots climbed into their machines and were up after it.

At once it moved off seaward, with our airmen in hot pursuit. Flight-Lieut. Hands and

Flight-Commander Nicholl chased it 60 miles out to sea, and twice succeeded in getting above it. They appeared like two wasps darting at a big bird flying in panic for its life. Actually, though, the L.13 showed such determined fight that though our airmen reached the positions they were aiming at, above the enemy, they were kept at such a height above by machine-gun fire, that their bombs and darts missed their mark, and the craft at last escaped. It was remarkable that our two airmen escaped the almost continuous hail of machine-gun bullets that swept about them from the gondola of the airship. Other airmen furiously attacked the German fleet, and though under severe and continuous gun-fire, got near enough to bomb some of the vessels.

Flight-Lieut. H. G. Hall and Flight-Lieut. D. C. Evans as passenger went so close over the enemy vessels, to drop their bombs, that the wings of their machine were riddled with bullet holes, and Flight-Lieut. Hall was hit in the shoulder. Even that did not send him down, for he continued worrying the enemy for another forty-five minutes, then returned to his air-station and collapsed from loss of blood.

Squadron-Commander Oliver, too, dared greatly. In his determination to drop his bombs

on the enemy he ran through such a fierce fire that at times his machine could not be seen for the smoke of the shrapnel shells as they burst around him.

Over two hundred houses were wrecked at Lowestoft, and then the enemy put about and steamed full speed for their bases, which they reached before our forces could cut them off.

For some time now the enemy were very quiet—far too quiet for our peace of mind.

As you may imagine, all sorts of rumours passed from mouth to mouth. A great attack, it was said, greater than any before, was to be launched. Group upon group of aircraft was to cripple our fleet, ravage our great cities and ports, and then descend upon London and so break the stubborn spirit of the people.

A Grim Struggle

At last a night came—the night of 3rd September—and with it the greatest array of enemy craft that as yet had attacked our land.

Whilst England was sleeping there were moving swiftly across the sea the L.11, L.13, L.14, L.16, L.17, L.21, L.22, L.23, L.24, L.30, L.32, S.L.32, S.L.11, L.Z.98, and they were carrying over twenty tons of bombs.

That was a night of deeds the memory of which can never fade from the minds of those who witnessed them.

What England would have suffered during those hours of darkness but for the skill and magnificent courage of Lieut. W. Leefe Robinson of No. 39 Squadron, R.F.C., is not difficult to imagine.

Most of the enemy airships had crossed the Norfolk coast, turned south-west, and bore down upon London. The drone of their engines could be heard overhead, and across that sound cut a higher note, the purr of our machines as they climbed to give battle.

The beams of silver light from many searchlights criss-crossed through the darkness, and went backwards and forwards swiftly hunting for the enemy. Suddenly one beam ceased to search, and moved steadily across the sky. The eyes of ten thousand watchers ran up that endless path of light, and were fixed upon the silvered object moving smoothly under the stars, and gazed and gazed unblinking. Yes, here was an airship caught and illuminated in the dreaded beam of a searchlight. It was a fly held by the single gossamer thread of a web. Frantically it struggled to release itself ere it became more entangled.

Another revealing ray swept across, cut the

first and lit the airship to a gleaming silver. Down it dropped to seek safety in a cloud. Relentlessly the beams held it. Shrapnel was bursting around it from a dozen anti-aircraft guns. Up it shot, up and up, changed direction, and then rushed seawards. All was unavailing. The beams held it. It was doomed.

Rapidly a fast single-seater fighter was climbing towards it. Nearer and nearer drew the attacking plane in a steep climb. Now it was almost on a level, and a fierce, desperate machine-gun fire was opened on it. Had there ever been beneath those stars so strange, so magnificent, so pitiable a spectacle?

The fleeing airship and the tiny plane rushing through the night; the slender silver threads running up from earth; the roaring of the engines, the sharp crack of shrapnel, the fierce rattle of machine-guns.

Life or death? And what a death. To come crashing down thousands of feet, crashing down maybe in roaring flames! To be hit and know that you were falling faster, faster, and that nothing could save you!

Were they not courageous, whose grim fight for life the stars were watching? Nearer and nearer the plane got to the enemy, and now suddenly the shrapnel shells ceased, the guns below were silent. Lieut. Robinson had been

seen by the searchlight crews and further fire by the anti-aircraft guns would have added to his peril.

Then up he shot in a swift, wide, circling climb, and now, untouched by the stream of bullets that hissed around him, was rushing along above the airship. The fascinated watchers, thousands of feet below, next saw a tiny spurt of light which leapt up suddenly into a great column of flame, and the next moment the S.L.11 was hurtling down to earth a roaring mass of blood-red fire, with a thick trail of flying sparks to mark its way.

It crashed into a field at Cuffley, a few miles from Enfield, and there burnt itself out. Every one of the crew perished, most probably burnt to death before the final crash.

Far greater than the destruction of one airship had been the achievement of Lieut. Robinson that night.

Other enemy airships were close enough to the ill-fated craft to know by the glare in the sky what had happened to it. Their confidence was shaken, their hearts chilled by the horror of their comrades' end, and putting about, they made for the coast and passed back over the sea.

The enemy airships operating in other districts dropped many bombs and did a con-

siderable amount of damage, but the raid failed completely in its great object. Instead of striking terror into the minds of the people, it filled them with a mighty confidence, for they now knew that the foe, hitherto terrible in the blackness of the night, could and would be revealed and destroyed.

Other hostile airships had been brought down, but this was the first one defeated and wrecked before the eyes of thousands.

In the Imperial War Museum is to be seen a small observation-car that belonged to one of the enemy airships that was making for London on this night. A tragic story belongs to it. A little time after the burning of S.L.11 this observation-car with the observer in it was lowered over the village of Mistley. How far down he dangled in the darkness at the end of the supporting cable is not known. Suddenly the cable snapped and down he went to a dreadful death. The shattered body, together with the car and nearly 5000 feet of cable, was discovered in a field close to the village.

Another Blow to the Enemy

Although the enemy well knew the probable fate that awaited them, they made another big raid on 23rd September. This time eleven

Zeppelins set off, the L.13, L.14, L.16, L.17, L.21, L.22, L.23, L.24, L.31, L.32, and L.33. They were again under the leadership of that daring Commander Mathy, on whom Fate seemed ever to smile.

Searchlights sought and found him and lost him again as he passed over London from south to north, bombing heavily as he went.

Numbers of our pilots were up after him, and one was surely overhauling him when he cleverly rose into a thick bank of cloud and was lost. He left a trail of death and damage, and passed back unharmed across our coast at Great Yarmouth, where he was unsuccessfully attacked again.

The L.33 flew over the East End of London, dropping bomb after bomb with deadly effect. Then the searchlights caught her, and the anti-aircraft guns opened fire.

The white puffs of shrapnel smoke crept nearer till it seemed they were brushing the very sides of the shining envelope.

And now rushing upward was a young lieutenant of the No. 39 Squadron, R.F.C., Second-Lieut. A. de B. Brandon, who had already figured in many an aerial fight. By the time he got within range of the enemy ship it had been hit but not disabled by shrapnel.

With fine judgment and magnificent dash he manœuvred for position, then blazed away. The airship faltered, fell, and righted itself. Lieut. Brandon followed it down and riddled it with bullets.

It dropped into a field near Peldon, catching fire as soon as it hit the ground. The crew, however, were unhurt, and were made prisoners of war. Another officer of 39 Squadron, Second Flight-Lieut. Sowrey, fought and won a great battle with Zeppelin L.32, which he shot down in flames over Dartford.

The Defeat of Kapitän-Leutnant Mathy

Thus two more of the enemy's craft had been destroyed, and the services of two highly trained crews lost, but Kapitän-Leutnant Mathy, the fearless, the iron-willed, had escaped, and would surely strike again.

He had made raid after raid on England, inflicted more damage than any other commander, and carried out a hundred reconnaissance flights over the North Sea, which had been invaluable to the German navy. His name was on the lips of our pilots in every air-station. His courage, his great skill, his seemingly charmed life made him a figure of romance, a foe of foes, against whom every one of our

knights of the air longed with a great longing to fight and vanquish.

And then at last his hour struck. On the night of 1st October a great raid by eleven Zeppelins was made on England, and in the L.31 came Kapitän-Leutnant Mathy. Nobody but he had commanded his ship, which had made its maiden flight only three months before. Warning of the coming of the enemy had been received at all our stations: search-light crews and gun-crews stood by; machines were run out of their sheds, and engines warmed up; pilots climbed into their cockpits and were strapped into their seats; the Mobile Anti-aircraft corps waited ready.

And others waited, waited, but how differently. They had sudden tremblings, sudden chill forebodings that blanched their faces even as they talked or went about their occupations. They sought their windows again and again, and the open air, and gazed up into the night as if to find there some solace for their heaviness of heart.

These were the wives and mothers waiting thus whilst brave men fought and killed. Oh the sadness and the madness of war!

And the wife of Kapitän-Leutnant Mathy waited too. He had returned so many times before, surely he would return again.

In the L.31, Mathy crossed our coast at Lowestoft at about 8 p.m., setting his course for Chelmsford. Three of our planes set off in pursuit, but he eluded them in the heavy mist. Soon the crash and flash of bursting bombs told of his presence over Cheshunt. On he went over Essex and Hertfordshire, and for forty minutes dodged the searchlights that swung to and fro across the sky, hunting the darkness for him.

Second-Lieut. W. J. Tempest, R.F.C., was one of several who, as they climbed from differing points through the patches of mist, unable to sight the enemy, prayed for a searchlight beam to pick him up.

And then it happened. A beam became suddenly steady, dropped slowly and evenly downwards, and there at last in the silver path swam the L. 31. In a few seconds anti-aircraft guns, finding the range, blazed away round after round, and splashed the dark background of the ship with those white puffs of shrapnel. Now Lieut. Tempest had a clear view, and went straight for it. Did Mathy and his crew see this young assailant speeding up to them, or was he upon them out of the darkness before they could beat him off? Their machine-guns, in the gondola, poured forth a stream of bullets.

. Too late, he was through it and up over them. The machine-guns on the platform on top of the envelope were now the only hope. But this was Lieut. Tempest's great hour. As he swept over, with unerring aim he dropped his bombs. The nose of the Zeppelin dropped, the whole ship dropped, a flame shot up from her, and the next moment she was rushing through the air, lit from stem to stern. She crashed in a field at Potters Bar. Every one of the crew perished, and Germany lost that night, in Kapitän-Leutnant Mathy, their most brilliant and fearless commander.

The Great Fight over Yarmouth

On a dull day in October (27th October, 1917), the enemy set out again for our shores. This time, ten naval airships formed the raiding fleet, and included the L.34, L.35, and L.36, the latest design of the L.30 class.

Great things had been expected of these new airships, which were much faster than the old designs, and had a static ceiling of 17,000 feet, and an increased lifting power of 14 tons.

They made for the Tyneside, and soon disaster came to them. The L.34 crossed the coast at the Black Hall Rocks, and was quickly engaged by Second-Lieut. I. V. Pyott of the No. 36 Squadron, R.F.C.

In a few minutes he had it crashing down to the sea in flames. The commanders of the sister ships, seeing the fate that had befallen the L.34, turned and fled for home. The glare of the burning airship was so intense that a pilot, patrolling one hundred and forty miles away, knew what had happened.

But now for the stirring fight with the L.21. This raider had at 9 p.m. crossed our coast near Atwick, and was making for the industrial district of northern England, when the guns of Barmston opened fire with such good effect that it was driven back out to sea. The Commander, though, was not the sort of man to be turned easily from his purpose, and his retreat seaward was made solely to enable him to find a safer way through our defences, and to shake off any of our machines that might have picked him up when the guns were shelling him. Satisfying himself that he was free from pursuit, he returned, passing unchallenged over the coastline a little south of Flamborough Head at 9.35 p.m. For the next three hours the monster prowled over the great Yorkshire manufacturing district which lay in utter darkness, not even a light within doors being permitted, and wherever possible even the fires in the grates being smothered or screened. On Wakefield and Barnsley, which only an

hour earlier had been bombed, the L.21 dropped more bombs, and then cruised over Macclesfield, Hanley, and Chesterton. With great confidence and no small courage the Commander ordered his ship about and took a course over Stoke and the famous hunting centre of Melton-Mowbray.

He well knew that dire vengeance might descend upon him at any minute, he well knew that hounds were somewhere chasing through the night for their quarry, and yet he lingered, taking a winding course at a leisurely speed to the coast, which he crossed, with a mixture of thankfulness and exultation in his heart, into what he thought would be safety.

So confident was he that he wirelessed a message to the commander of his base that all was well, and he was now bringing his command home.

Not many minutes after that reassuring message had gone off, the Commander and all his crew were dead and his airship a burnt-out wreck beneath the sea.

When the Commander, Kapitän-Leutnant Frankenberg, had turned to cross back over the coast, the warning had come through at five in the morning to Lowestoft. The enemy craft had passed over Swaffham, then over Dereham,

and so its intended course was almost certain to be over Yarmouth.

The whole station had been standing by all the night, and now Flight-Lieut. Cadbury set off in his B.E.2c to intercept the approaching Zeppelin. Only a few minutes before, another pilot, Flight-Sub-Lieut. Pulling had had orders to leave Bacton and patrol for an hour. Lieut. Cadbury had not been up many minutes before he had engine trouble and had to come down at the night-landing ground at Burgh Castle. There he found Flight-Sub-Lieut. Fane, a mere youth, still in his teens, who had been flying for hours in a vain attempt to find the enemy, and had landed at Burgh Castle to fill up with petrol and oil.

How nearly the L.21 escaped that night! Whilst it was speeding towards the coast and safety, two of the three sent out to cut it off, Cadbury and Fane, were on the ground, and only Pulling was up.

The night, or rather the morning, was intensely cold and there was a slight mist seaward. Fane's engine was cold and would not start up. Whilst the mechanics got hot bricks to warm the induction pipe, others were changing the plugs of Lieut. Cadbury's engine. The two airmen stood there in the cold dark morning speaking of the coming Zeppelin.

LIEUT. WARNEFORD'S GREAT EXPLOIT: THE FIRST ZEPPELIN TO BE BROUGHT DOWN BY THE ALLIED AIRCRAFT (JUNE 7th, 1915)

From the painting by Gordon Crosby

At last Fane got away, steering for Lowestoft, and at 6500 feet started to patrol between Yarmouth and Lowestoft, as he was certain the enemy would cross the coast somewhere between those two points. It was getting towards dawn and the Zeppelin could not afford time to seek a safer way out.

New sparking-plugs had now been fitted to Cadbury's engine, and he too took off and went up in a steep climb.

It was now that the Commander of the Zeppelin, quite unaware of the proximity of the three English airmen, had sent his "all well" message.

Cadbury sighted the L.21 first, going out to sea, and gave chase. Pulling was about to descend from a height of 9000 feet, having seen nothing of the enemy, when suddenly the anti-aircraft guns near Yarmouth opened fire. Here was the enemy at last.

He steered south-east, leaving the flashing guns on his right, and rose rapidly to 8000 feet. Out over the sombre sea and through the cold darkness he rushed, and then to his straining eyes came the dim outline of the fleeing airship. He did not move his eyes; nor scarcely blinked. What he saw opened them wider. The Zeppelin was being attacked by a plane, invisible to him, but firing tracer bullets which cut

clear across the vast background of blackness.

He was fast overhauling the enemy. Only 500 feet separated pursued and pursuer—now only 200, now only 100. He was level with the Zeppelin at 8000 feet, and approaching her at right angles on her port quarters. A stream of bullets whistled about him, cut through the fuselage and left him unhurt even at this perilously short range. Now he turned to the left, and as he swept beneath at only about 50 feet, fired two shots into her. Two shots only, for his Lewis gun had jammed.

Heavy fire was opened on him from the gondola, and to get out of range and clear the jam of his gun, he made a wide sweep, and then looking back over his shoulder, saw that the Zeppelin was on fire by the stern.

This was the work of that attacker whose tracer bullets Pulling had seen before he himself had got into action. That attacker was Lieut. Cadbury, whom you last saw waiting impatiently for his plugs to be changed. He had " got under her at about 700 feet distance and fired his Lewis gun into the after-part of her, under heavy fire from the Zeppelin ". A whole tray of ammunition Cadbury emptied into the Zeppelin, and as that did not stop it, he put on another, and another, and a fourth,

and now all his ammunition was gone, and still the enemy travelled on.

Only a minute or so before that, Lieut. Fane had joined in the attack. He had left Cadbury at the night landing-place, and had soon sighted the enemy. "I soon sighted her," he said, "about 2000 feet higher than I was, going out to sea, and started in pursuit. After a short time I had got to her level about a mile away, and finally I got myself into a position just under her tail, and within 30 feet of it, and started firing at her. I only got off one round, however, when the gun jammed" (you remember Pulling's too had jammed), "and so I soon cleared out of the position I was in, owing to the fact that I was right in the slipstream of her five propellers, which made the machine very difficult to control, and also there was another machine some way below me firing like mad, and evidently could not see me; this turned out to be Cadbury. I then endeavoured to clear the jam in the gun, but I was not able to do it in the excitement of the moment, so I set about getting above the Zeppelin to bomb it. Having got to about 500 feet higher than the airship, I turned to cross over and drop all my bombs on her."

It was then that he too saw flames coming from the stern of the vessel.

All three officers must have had hairbreadth escapes.

Lieut. Fane was so close that he plainly saw two of the enemy trying to train a machine-gun on him as he was chasing along beneath. He owed his life probably to the fact that the machine-gun stops did not allow sufficient transverse movement for the gunners to get their sights on him.

When the airship burst into flames, his face and the fuselage of his machine were badly scorched. As he passed over the ship the machine-gunner in the cockpit on the top fired at him, then seeing the flames leap up, stopped firing and " ran straight over the nose of the ship, just before she exploded and disappeared ".

Another of the crew of the airship continued to fire his gun at Pulling until he was completely wrapped in flames.

Then the ship exploded and went rushing down, a blazing mass, to the sea beneath.

Adventure with the Flying-boat

It was only three o'clock on the 14th May, 1917, when the flying-boat H.12 8666 rose with a roar from Great Yarmouth station and was almost at once swallowed up in the cold grey mist. What adventure was on hand?

The navigator was Flight-Lieut. Galpin; the pilot was Flight-Sub-Lieut. Leckie, C.P.O. V. F. Whatling had charge of the wireless, and A.M. O. R. Laycock was the engineer.

Their craft was armed with three Lewis guns and four 100-lb. bombs, and those four daring spirits were off to pay a surprise visit to the enemy. They were going to stir him up. Who could tell what splendid adventure would befall? They would rush through the miles of mist and out into what sudden danger!

The uncertainty only added zest to the game. Perhaps the enemy would be out too, and in great force. They might run into an ambush; their craft be sent crashing down to the cold waters beneath; they might be wounded and bleeding and left to die slowly in torture, tossed about upon the waves. The very thought chills the marrow.

But these four had made their plans, and went off with the glowing hearts of schoolboys bent on a dawn raid of an orchard, and smiled, one to another, as the thought came to the mind of the surprise they had in store for the enemy.

When they had gone about eighty miles, Galpin took over the piloting to rest Leckie, and it was decided to send out no more wireless messages lest they should give away their

position to the enemy and bring a whole fleet of craft about their ears.

So far nothing exciting had come their way. They were cruising along 6000 feet up, at about 60 knots, scanning the misty blue waters beneath and the pearly grey space around them. For all they saw they might have been, at this dawn hour, the only living things in a boundless waste of air and sea.

A thick bank of mist reared up before them. Through it they ploughed blindly, the roar of the engines dinning in their ears, the fog chilling their bodies, the walls of grey gliding past them and producing a feeling of giddiness. Ten minutes and they were through into the light again. And now all eyes were glued to an object forward. There, maybe ten miles ahead, moved a Zeppelin. It was end on. Was it coming towards them or going away? Lieut. Leckie, who was at the wheel again, increased speed, Whatling went aft to the rear gun, Galpin moved to the two guns mounted parallel in the bows, and the engineer stood by, ready.

When they had first spotted her, the Zeppelin was coming towards them. Now they saw her broadside as she turned north and went away to the north-east. More speed, then more speed.

Overboard went three of their four bombs to

lighten their craft. Had the enemy seen them and was she flying to safety? Would she outspeed them? Would she fight or rise swiftly and wireless a call for help?

They were 2000 feet higher than the Zeppelin and tearing along at 75 knots. Only two miles lay between. Down they swept a thousand feet. The background of dull, angry-looking cloud out of which they had come must be making their approach invisible, for still the enemy gave no sign of having seen them. The distance between decreased. Two miles, a mile and a half, one mile, half a mile, and then—— Like a giant springing up in sudden dismay before a quick, fierce foe, the Zeppelin put up her nose, dropped water ballast that spread out like a smoke-screen, and shot up.

The fight had begun. Leckie sent the H.12 8666 down into a steep dive at 90 knots, coming up astern of the airship and about 30 feet beneath her gondola level.

Quickly they overhauled her. Restraining himself with the utmost difficulty, Galpin, in the bows, waited till they were only some 40 yards off, and then blazed away with both bow guns.

Incendiary bullets pierced the envelope on the starboard quarter. Then Galpin's port gun jammed, then his starboard gun. The four

were now in a perilous position, sweeping along with both guns jammed, only 20 yards from the gondolas, from which now machine-gun fire was pouring.

At such a time the quick decision of the pilot makes all the difference between victory and defeat, and instantly Leckie turned away to the starboard, whilst Galpin tried to clear his guns. Leckie meant to sweep round and come under her again, but there was no need. A glow appeared in her middle under-quarter, where Galpin's bullets had struck. As they swept back, they saw the glow increase, then fire leap and sweep upward.

For a second or two the great ship hung shuddering, then rushed down in a roaring sheet of flame. Before she hit the sea, her engines, burnt out from their fittings, sent up great columns of water as they crashed. Then with a hissing scream the glowing framework plunged out of sight, and all that was left of the L.22 was a round patch of oil and black ash upon the water.

The four adventurers circled for a time over the spot, but nothing rose upon the surface, and they set their course for home. Bullet-holes through the wings and the hull of their craft proved how kindly Fate had treated them. That, then, was the first, but by no

means the last adventure with the H.12 8666, as you shall see.

Disaster

For some time the 8666 had been doing such excellent work that it was now famous, and feared by the enemy.

Then came a day in September, when with the D.H.4 it set off to attack some enemy airships that had been reported off Terschelling Island. The D.H.4 land-machine was a very fast craft and a most formidable fighter, but it had no floats of any kind, and therefore a flight of six hours over the North Sea was an extremely hazardous operation. It had but to be sent down by engine trouble or by any one of the hundred mishaps that might befall during a 500-mile journey, and but for a slight chance of a friendly vessel, there was nothing but drowning for the crew.

Therefore it was decided to employ 8666 as an escort which would not only support D.H.4 in action, but act as rescue craft in the event of its being forced down. Moreover, it would relieve D.H.4 of the difficult and exacting task of navigation.

Away they sped to Terschelling Island, Squadron-Commander Nicholl being in command of 8666, with Flight-Lieut. Leckie again

its pilot, Air-Mechanic Thompson in charge of the wireless, and Air-Mechanic Walker as engineer.

Lieuts. Trewin and Gilligan were in D.H.4. They were only there by good luck, for when they had arrived at the taking-off ground, they found Lieuts. Fane and Betts in a machine with engine running all ready to start. All four of them could not go, and each pair insisted on going, so they tossed for the honour, and Gilligan won.

Steadily they flew for an hour and a half with 8666 leading and climbing very gradually to attain her ceiling of 12,000 feet, by the time they reached Terschelling Island.

At noon, when they were at 9000 feet, the D.H.4 received the signal by Aldis Lamp from the 8666: "Climb as high as possible and attack Zeppelins."

This came as a great surprise to Gilligan and Trewin, who had not observed anything resembling a Zeppelin. They therefore signalled back: "Yes, but where are the Zeppelins?"

Back came the reply: "Dead ahead. Close and attack."

That meant that D.H.4 and 8666 were about on a level with the enemy airships, which proved to be the L.46 and L.44. The L.46 was some miles away, and, putting about,

made for Borkum, presumably to bring out reinforcements.

Immediately the D.H.4 prepared for action, and Gilligan sent her climbing up to get above the L.44 and dive upon it.

But the Zeppelin was already ascending rapidly, to defeat this manœuvre, and so Commander Nicholl in the 8666 made straight for it and opened fire. He says: "At 12.30 p.m. I opened fire on the Zeppelin, our altitude was 12,000 feet and the Zeppelin's 14,000 feet. She dropped water ballast and climbed still higher. The Zeppelin's number was L.44. I continued attacking unsuccessfully for one hour, firing four hundred rounds of anti-Zeppelin ammunition. The tracers were seen hitting the Zeppelin. During most of this time we were subjected to a heavy machine-gun fire from the Zeppelin.

"The Zeppelin, in the meantime, led me over a squadron of two light-cruisers and four destroyers, which did not open fire, presumably on account of the proximity of the Zeppelin. The D.H.4 was some distance away and was endeavouring to climb higher, and at 1.30 p.m. signalled me that his engine was not pulling well and he could not climb any higher than 14,000 feet. I then signalled him to close and attack the Zeppelin, which he did without result."

Although Gilligan and Trewin in the D.H.4 made a determined attack on the Zeppelin and fired many rounds of ammunition, none of the bullets seemed to take effect, and all the while the airship L.44 was throwing out ballast and rising rapidly. Its commander had cleverly manœuvred, for having led his attacks right over the cruiser squadron, he had risen out of danger, then flown away, leaving his enemy within range of the German warship guns, which now opened a fierce and accurate fire.

Suddenly, to Gilligan's and Trewin's consternation, the air-screw stopped, and all their efforts failed to set it going again.

The position was indeed serious. They were many miles from home, over enemy waters, with enemy cruisers and destroyers and minesweepers spread out beneath at distances of ten miles.

Gilligan signalled engine trouble to 8666, and Commander Nicholl answered: "Follow me, try to make Yarmouth."

Gilligan and Trewin received the message with a grim smile. Only too well did they know that their D.H.4 would never make Yarmouth. Their engine had seized up, the radiator having been pierced by a bullet, and even now they were running down to the white-crested waters.

What was more, the 8666 too was lamed.

Enemy fire had damaged one of her magnetoes, and now only one set of cylinders was firing.

A heavy sea was running, and as Trewin and Gilligan came gliding down, it came up to meet them. "I took my chance," said Gilligan, "about 70 feet up 'pancaked'—a horrid crash and all I could see was blue water above. I could not free myself, and after trying everything (for I had blown up my waistcoat before crashing) I suddenly remembered my headphone attachment was still plugged in—this was all that was keeping me down. As soon as I disconnected it, up I shot, to find Trewin swimming towards the relics of the machine."

Gilligan and Trewin had tossed with Fane and Betts and won—won this! The 8666 was perhaps 5000 feet up when D.H.4 crashed into the sea. Nicholl and Leckie did not hesitate one moment.

A heavy sea was running, their own engine was defective, their petrol was running low, the enemy was in the close neighbourhood and knew of their helplessness, their wireless was out of action, and they were without food.

But Nicholl and Leckie did not hesitate—not for one moment.

Leckie sent the 8666 down in such a steep dive that it got into a spin, and only just escaped the fate of D.H.4.

Gilligan and Trewin, seeing the 8666 coming down to them, left the wreckage and swam to meet it, without casting off their heavy flying-garb. Gilligan scrambled up into the flying-boat, but Trewin, who had nearly been beaten, was hauled aboard in a state of collapse.

Had Nicholl and Leckie made for home, to send out relief vessels and planes, as they might have done, Gilligan and Trewin would have been lost.

But now there were six aboard the flying-boat, and as Leckie and Nicholl had known, it could not rise from the water, and the only thing to be done was to set a course and attempt to "taxi" home, with the hope of being picked up by a friendly craft.

. . . . . .

As the afternoon wore on and the adventurers had not returned, the Yarmouth station sent out machines and directed patrolling vessels to extend their beats. Anxiety increased when the evening brought no message.

Destroyers, drifters, motor-launches, and trawlers were sent out on the search, and destroyers left to explore the waters around Terschelling. Darkness came, and impatiently the searchers awaited the dawn. Every available aircraft now joined in the hunt, one seaplane going right to Terschelling, searching the

sea around, and coming back on the course most likely to be taken by the missing aircraft.

Still there was no sign. All through that day (Thursday), all through the night, and up till ten o'clock on Friday morning not a word had come from the lost ones.

Then, over forty-six hours after they had set out, a pigeon brought this message to the station: "3 p.m. Very urgent. Seaplane 8666 to C.O. Air Station, Great Yarmouth. We have sighted nothing. The wind has been drifting us west-north-west ever since we landed, so we may have missed Cromer. We are not far from the coast, as we keep seeing small land-birds. Sea is still rough. Machine intact still. We will fire Very lights every 45 minutes to-night. V. Nicholl."

All through that Friday the North Sea area where there was any likelihood of finding the 8666 was patrolled with redoubled energy, but without result.

No word came through the night, and the next morning, after three days and nights, through which surely the 8666 could not have survived, the Admiralty had decided regretfully to abandon the search.

But Lieut.-Commander B. S. Bannerman, of H.M. gunboat *Halcyon*, would not abandon hope, after having seen the pigeon-message with

its " May have missed Cromer ". From calculations of wind and speed, the run of the sea, and the position of the attacked Zeppelin, he decided that Nicholl and his party, if they had taxied towards England, should be somewhere north of Cromer.

During all the remaining hours of light of that Friday he steamed away along the coast northwards, keeping the sharpest lookout for any sign of the lost craft, and still when darkness fell he was disappointed. He lay off the Haisborough Light Vessel and awaited the dawn.

. . . . . .

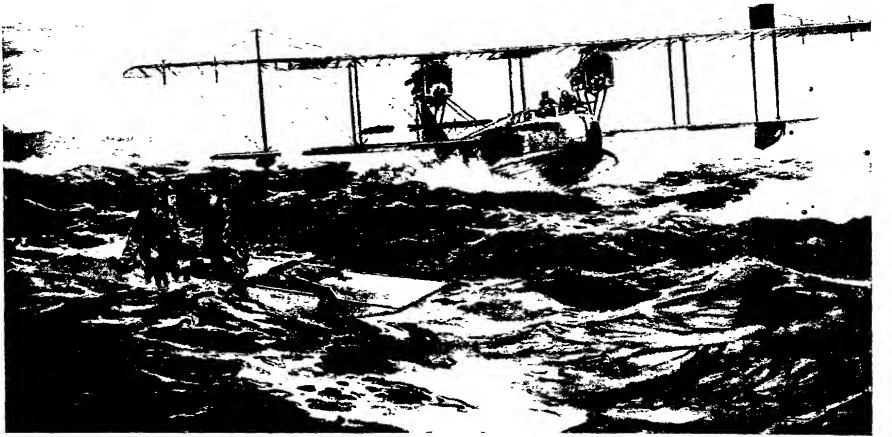
What had happened to the 8666? A great waste of water stretched around, stormy, grey, forbidding.

Six pairs of eyes anxiously swept around for some sign to hearten them.

There was none.

They could not escape the desolate feeling that they were the only living beings in an endless space of tumbling waters.

Their craft, holed by a shell fragment whilst over the enemy's cruisers, was badly leaking; they had no food, there was but one tin of water, petrol was running low; they were heavily overloaded. Could conditions have been much worse?



E 628

ALMOST A RESURRECTION: AN H.12 FLYING-BOAT RESCUING A WRECKED SEAPLANE'S CREW

From the painting by C. Fleming Williams

Facing p. 64

The water was flooding in. They bailed for their lives, but the following sea continually lifted the tail and plunged the nose downwards, so that their labours were in vain. To keep this course was fatal, so Leckie turned N.N.E. They were up to their knees in water, and bailed, and bailed, and bailed. Their wireless apparatus was useless, but there was one hope—the four carrier pigeons.

Nicholl sent off two with this message: "H.12N.8666. We have landed to pick up D.H.4 crew about 50 E. by N. of Yarmouth. Sea too rough to get off. Will you please send for us as soon as possible as the boat is leaking? We are taxi-ing W. by S. V. Nicholl."

Their hearts fell as the one sound engine spluttered and failed. The petrol was used up!

As they drifted, drenched to the skin, cold, hungry, and continually sea-sick, they bailed with tins as hard as their tired arms would move. The waves slapped across the craft, chilling them to the bone, and the sharp, salt-laden wind stung their eyes and cracked the skin of their faces and necks.

Night crept down upon them, tossing them in their leaking craft. Suddenly the machine tipped sideways and fell back again, the sea-

sawing being repeated with each lifting wave. Here was a fresh peril—the starboard wing-tip float had been washed away, and the wing was dipping dangerously beneath the surface.

It meant that somebody had to lie out on the opposite wing to steady the craft and prevent the floatless wing dipping.

So, all through those dark hours, all through the dreadful hours of the next day, and still on through another terrifying night, and yet another, they took turns of two hours at lying out on the wing and gripping a strut, whilst the icy water every other minute washed over them. That they could endure such misery and keep their reason is to be marvelled at. Leckie was so sick that he ruptured a blood-vessel and was spitting blood; Trewin, who had been almost drowned at the outset, was in a state of exhaustion, and yet sat holding the tiller, with water often up to his knees. They had tobacco with them, but they dared not even seek consolation in a smoke, which would have increased their already torturing thirst.

So there they were, then, their eyes hollow, their cheeks sunken; all their strength being washed and frozen out of them; faint for want of food, burning with thirst, sick and weary and stricken.

But always, in the most desperate moments, when resolution had ebbed away and they wished to give up the struggle, the spirit would leap up in one or the other, and he would cheer and encourage his companions to fresh endurance.

And there was hope, ever the last thing to desert us. Had they not sent off two pigeons which even now might have delivered their message? Yes, those birds would surely save them; in a few hours now a seaplane or a vessel would come to their rescue.

So they hoped on, and one pigeon was never seen again, whilst the other brave bird with its message was picked up dead some miles from the station and not until the following morning.

Hour after hour they drifted on. They had no anchor and tried to make one of petrol cans and a few odd fittings, but without success. Their thirst was driving them mad, and they went in turn and slaked their parched tongues and throats with the rusty, unclean water from the radiator.

On Thursday afternoon, at 3 o'clock, Nicholl wrote the message already quoted.

This was their last hope of summoning aid, and then the minutes dragged like hours, and every hour became a day, and they forgot the

time when they had not been bailing, had not been washed by the pitiless waves, had not been suffering thirst and hunger.

Wednesday, Thursday, Friday, and now Saturday.

The lid of night was slowly lifting again; a haze of soft pearly light was creeping under, and spreading across the dark waters to them. Another dawn had come—the last, no doubt, for them—and showed the despair that each strove so hard to hide from the others.

Wild eyes stared around, and closed, and stared again. But steady, what was there—over there in the greyness?

The form of a vessel, surely the form of a vessel, and another and another.

Were they coming towards them or going away?

Hope gave a flicker and died again: those distant forms had slowly melted into wisps of fleecy cloud. The broadening light was playing tricks with them; their eyes were cheating them. A few more hours and——

And then came, at 10.30, the reward of all their splendid courage and endurance.

Out of the mist, towards them, a dim shape crept, grew darker, took on an outline, grew to a ship. A rousing cheer came to them across the intervening sea. They tried to cheer back,

but their voices cracked in their throats and only a weak, broken cry went forth.

Commander Bannerman in H.M.S. *Halcyon* —he who would not give up the search after seeing their second message brought on the Friday morning—had found them. Quickly those six brave men were lifted aboard and placed in the care of the doctor.

When they reached Yarmouth they were put to bed, and the very next morning Nicholl went up for a short flight to see, as he said, that his nerves were all right, and only three months later he was out again in the 8666, Terschelling way, after Zeppelins.

What a man!

In appreciation and admiration of the courage of the carrier-pigeon that had dropped dead after reaching land with his message, he had the bird stuffed and placed in the mess above this inscription:

"A very gallant gentleman."

Thus did one hero honour another.

PART II

The Exploits of the Caterpillar Club[1]

Those who "borrow" Time

After more than four long, weary years, the War ended, but the heroism that ran its golden threads through all those black days gleams unbroken through the pattern of these later times.

There is surely no club in the whole wide world which a spirited youth would like to join more than the Caterpillar Club.

A new member joined not many weeks ago. He may be said to have fainted into membership, for it was when he was flying at 17,000 feet that he lost consciousness and came shooting down to earth. He awoke just in time to jump from his spinning plane and open his parachute.

The members are all heroes, though they themselves would laugh at such a suggestion,

[1] The section "Exploits of the Caterpillar Club" is reproduced by kind permission of the Editor of *Pearson's Magazine*, in which journal it first appeared.

as indeed heroes always will. They leap at 10,000 feet from planes that are on fire, or have lost a rudder, or are in uncontrollable spins that make them giddy. They dive into fog, or blinding rain and snow, not knowing if the parachute will open, and if it does, not knowing whether they will alight on jagged rocks, or in the sea, or in impenetrable forest.

If they escape death, they have gained membership, and may wear the coveted club badge, a small golden tiepin in the form of a caterpillar.

To save your life, then, by leaping from a disabled aeroplane and drifting down to safety on the silken cords of a parachute is the only way of joining the Caterpillars, and therefore it is safe to say that there are no faint-hearts among the members, who number over five hundred and represent many nations.

It is impossible to read the official records of their adventures without experiencing a stirring of the blood, a quickening of the heart, and a sense of pride in living in this age with men so greatly daring.

They speak jestingly of their adventures, as if they had done nothing finer than come safely back from a boating excursion on a park lake.

Thus, they do not dive out of their planes but " bail out "; and the chute is not opened

but "cracked"; and the rest of their lives is "borrowed time".

The Coming of the First Caterpillar

Whilst on a test flight in a new Morse machine, Lieut. R. Harris, of the American army, engaged in a mock duel with a colleague, Lieut. Fairchild. Here is Lieut. Harris's own vivid story of what happened: "Lieut. Fairchild started a very slight turn to the left and I followed, keeping the ring and beadsight on his machine. The turn could not have been of a smaller radius than one and a half miles; in fact, I was banked at such a small angle that the pilot would normally not think of any motion of the ailerons." (Ailerons are small flaps on the trailing edges of the wings, which the pilot operates by moving the control-column or joy-stick sideways, to tilt the machine laterally, as when banking for a curve, or levelling up afterwards.) "As soon, however, as the airplane banked about two degrees, a terrific lateral vibration was felt, shaking the whole plane.

"The longitudinal control was still intact, and an attempt was made, by closing the throttle and climbing, to decrease speed and regain lateral control. This was found to be impossible, and the control-column knocked my

hand clear with its extremely rapid lateral oscillations. The control-stick was hunting from one extreme of the cockpit to the other, and severely bruised my legs just above the knees.

"As soon as it was discovered that control was completely lost, I opened my belt" (the safety-belt strapping him to the seat) "and slid out through the top of the fuselage, clear of the airplane. The wind velocity at this time was very high, and no effort was necessary to leave the cockpit, as the wind sweeping up, carried my body absolutely free. . . . Particles of wing or ailerons were flying from the left wing before I left the airplane.

"After clearing the airplane, an effort was made to operate the parachute rip-cord, but I was unable to locate the ring for some considerable time, on account of repeatedly grasping the leg-strap fitting, thinking it was the release-ring. Three separate attempts were made before the ring was located, and it is believed that during this time my body was spinning, head downward, and I distinctly remember looking at my feet three times, with the knowledge that they were pointing towards the sky. Upon the operation of the rip-cord, the parachute opened almost immediately, but with a considerable jerk. I have no means of

knowing how high I was at the time the parachute opened, except the description of eye-witnesses and the fact that from the time of the opening to the time I landed was an extremely short period.

"In the parachute descent it was remembered that in landing the legs should be pulled up for the purpose of acting as a spring for the landing, and the harness grasped by the arms to secure an additional spring.

"Fortunately, no trees or houses were encountered, but the landing was made on a fragile grape-arbor, which easily gave way and nicely broke the fall to the brick pavement below.

"An interesting feature of the descent, before the parachute opened, was the fact that the mental faculties were perfectly active, and perfect control was maintained of the arms and legs in spite of the probable rapidity of the descent. No feeling of relief occurred when the parachute opened: this point seemed to be simply another interesting phenomenon of the whole operation."

The pull-ring referred to is attached to a short length of cord which opens the pack and releases the chute. The harness which bears the weight, made of a specially prepared webbing of great strength attached to high-grade

steel fittings, is put on before the flight. The parachute, of fine quality silk, takes the weight of the falling body through silken shroud-lines. Both chute and lines are folded and placed in the pack, which may be of three types, to be worn on the back, in front, or as a seat, as desired. The actual operation of the chute is simple, as it may well be, considering the conditions under which it is used. The wearer jumps or is blown off the plane, and having allowed a few seconds, that there may be no danger of the chute being fouled, pulls the ring. The pack flies open, the chute is released and in $1\frac{2}{5}$ seconds is fully open. The actual rate of descent depends on the size of the chute, but an average value is 21 feet per second, which will give a landing force equivalent to a jump from a ten-foot wall.

Wings Break Off at 3000 Feet

Imagine the horror of seeing your wings float away when you are 3000 feet up.

That was the terrifying experience of Flying-Officer D. R. Byrne, which plunged him into membership.

He was stunting, doing the forward loop, which is a far more difficult and dangerous evolution than the ordinary loop, for instead of swooping up, over, and down again to the

normal, the nose is sent down so that the machine makes a complete downward curve, coming up and over to an even keel.

The craft had been behaving perfectly, answering the slightest movements of the controls, and confidently Lieut. Byrne sent her down into a graceful curve. When she was at the bottom of the loop, and therefore inverted, so that the airman's head was pointing to earth, he was startled by a sudden crackling of wood, and, turning his head, saw his wings floating away behind him.

Here was he, upside down, shooting through the air at something like 150 miles an hour, and strapped securely to a roaring machine over which he had not the slightest control. To add to the predicament, the plane got into a spin and then dived.

In such a nightmare crisis thought must be instantaneous. The plane was rushing down at terrific speed, and a mighty wind sounded in his ears.

Rapidly he released his safety-belt strapping him to the cockpit seat, then switching off the engine and giving one swift glance downward, with his right hand on the rip-cord ring, he swung a leg over the side and was immediately swept out into space. Down he went like a stone, until he had counted three, when he

gave a pull on the parachute rip-cord ring. At once there was a rush of silk past him, a resounding crack as the chute filled with air and he was brought up straight with a jerk.

And now he was floating down smoothly through a profound quietness, for the engine was not dinning in his ears, nor were there any earth sounds coming up to him.

His thoughts turned to his machine. Where was it? Would it go crashing into some crowded place? Was he to be the unwilling instrument of perhaps a dozen tragedies? He looked around, and to his great relief saw the plane, after just missing a tree, crash harmlessly into a field.

A few seconds after, he himself landed safely on the aerodrome.

The stunt that Lieut. Byrne was attempting was first shown in England by the German crack Herr Feiseler, at Blackpool, and his exhibition had an amusing sequel.

He had gone successfully through the evolution, for which, by the way, he was paid three hundred pounds, when the spectators became aware of a plane approaching which began an exhibition certainly not appearing on the programme. The two uninvited airmen gave a splendid show, and then, to the amazement of even the flying-men present, went

through the hazardous and original manœuvre of the German pilot. It seems that they had seen an account of his stunt, written by himself, in a newspaper, and just thought that they too would amuse the Blackpool folk. They were Flying-Officers Boyle and Atcherley, the latter now of Schneider Trophy fame.

A Padre Drops In

Up to the time of writing there is only one padre who enjoys the distinction of wearing the little golden caterpillar, and he is Squadron-Leader K. C. H. Warner, chaplain to the R.A.F. in Egypt.

With a pilot, he set off from Abu Surir for a 70-mile flight across the desert to Cairo. They were travelling steadily at 1500 feet when suddenly the engine-shaft broke. The vibrations of the damaged engine loosened it from its bearings, and soon the craft was out of control and spinning down fast.

There is great danger in a spinning plane of the occupants becoming dizzy, and bungling the jump and subsequent opening of the chute. When the craft had spun down to 1000 feet, the pilot signalled to the padre and went over the side. The padre was not slow to follow, and what happened then he tells thus: "I saw the pilot's body fall over and over towards

the desert, until suddenly there was a puff of white, and a beautiful silk parachute flashed out to check his fall.

" Releasing my safety-belt, I lifted my leg out of the cockpit and fell out of the spinning plane. Instead of experiencing the sensation of falling, I seemed to be floating gently on an air-cushion, in a horizontal position.

" I fumbled at my right side for the metal ring and pulled sharply, and almost before I had finished, I found myself jerked upright beneath the gleaming silk canopy.

" As I floated down without any sign of movement, I had a wonderful view of the desert. Far below, the white parachute of my pilot was gently swinging near the sand. Then it suddenly sprawled out and I knew he was safe.

" Soon afterwards the sand appeared to be rushing up to meet me, and also widening out rapidly, and before I could brace myself, I came down on my shoulder, but without suffering any severe shock."

In sharp contrast to the padre's peaceful descent was the experience of Flight-Lieut. S. L. Pope. Here was one of splendid physique, scaling over fourteen stone, who had never " jumped " before, and indeed had not even studied the art of parachuting. He was testing

a Parnell single-seater, and having to land as the rudder was not acting well, was in a dive at 160 miles per hour and about 1000 feet up. He felt something happen, and looking behind, saw his rudder and fin floating away!

He shut off the engine, set the craft into a climb, to gain a safer altitude for jumping, and shot his hand to the safety-belt. Finding what he thought was the string attached to the release-pin of the belt, he pulled hard. Nothing happened. He was still firmly belted to the seat. Then he saw the earth in front of him, and realized in a flash that he was upside down. His plane had turned turtle and he was now rushing to earth, firmly strapped in an inverted craft.

How many seconds left? With the utmost difficulty he bent his head forward, and then found that he had been pulling the string of his notebook. Seeing now the right string, he pulled it. But still he was a prisoner. The new strap refused to run over the stub-pin.

And now he had to release the strap, hole by hole, whilst the relentless moments dribbled away. At last he was free. The earth was rushing up to meet him. He felt for the ring of the rip-cord. It was not in its place. What malignant power was at work this day?

The ring had been displaced during his

struggles and now dangled somewhere by his knees. He bent forward, groped for it, found it, lost it again. Then he had it firmly and tugged hard. The chute came rushing out, and opened with a crack like a gun. Travelling at that great speed and with his exceptional weight, he felt certain that the strain had torn the harness from the chute. Well, if it was so, it was. He glanced up and had the welcome surprise of seeing the canopy perfectly spread and the shroud-lines intact. But the test of his coolness was not yet ended. He was dropping into a great oak. Instantly he pulled on the shroud-lines to try to divert the chute. He was just in time, for as he swished past a thick bough struck his leg. A moment, and he came to earth with a heavy bump, for he had forgotten to release the shroud-lines, and so had reduced the surface of the chute.

Lieut. Pope considered, perhaps rightly, that he had a lot to be thankful for, and that it would not be bad form to show a warmth of feeling for his Irvin parachute.

Fire at 4000 Feet

The most dreaded of all entrance-fees to the Caterpillar Club was paid by Flying-Officer Leslie C. Bennett whilst with the No. 1 Fighting Squadron at Northolt.

On this memorable occasion, he was with his squadron in the air-manœuvres, and was flying in formation in the Richmond district. As Kew was approached, a whiff of petrol fumes came to him. He sniffed anxiously. There was no doubt about it, fumes were filling the cockpit. What had happened? Was a petrol-lead leaking, or was it even some worse trouble? His eyes swept down, and now they smarted with the fumes. Almost before he had come to a decision as how best to act, flames leapt up around him.

Had his safety-belt stuck, he had been lost, but he was free, and as he leapt, his machine was completely enveloped in a roaring column of fire. Down he somersaulted, waiting with hand on the ring, till he felt he was clear, then pulled on the rip-cord. The chute bustled out of its pack, and spread above him. But now he was assailed by a fresh anxiety, for beneath him lay the crowded district of Kew. He was dropping down smoothly, but where would he land, and where, alas, would his plane crash, that was now a red-hot mass?

Slowly it seemed at first he dropped downward to the house-tops, then as he got nearer they rushed up to meet him. He made a last effort, by pulling on the shroud-lines, to come down in the roadway, and then suddenly

realized that he was sprawling dazed in the middle of a roof, with the silken canopy spread out about him. He clutched at a chimney-stack to save himself from falling over into the street, gathered up the chute into its pack, and slid down the slates to a most convenient water-pipe, and thence into safety through a bedroom window.

Meanwhile, his plane, continuing its fiery flight, had fallen on the Thames towing-path and there burnt itself out.

When you read the records of these modern adventurers, you are struck by the fact that rarely does the abandoned plane cause injury or damage. Almost invariably it finds some open space in which to crash, even though the pilot be forced to drop upon a roof or into somebody's back garden. Not alone is this due to coincidence: credit is due most often to the pilot, who, partly for his own safety and partly for others', will stick to his craft until he has directed it towards open country.

Etiquette of the Air

In spite of the imperative necessity to act with lightning decision, there is an unwritten etiquette of the air, as strict and fine as that of the sea.

The pilot gives a warning to his passenger

to jump, as soon as he has decided to abandon the craft, and what is more, satisfies himself, whenever possible, that his order to jump is taken.

In one instance, the order to "bail out" was given, and the pilot, in the act of diving out himself, saw that his passenger was so completely paralysed by fear that he was making no effort to release his safety-belt. They were going down at possibly 200 m.p.h. in a straight dive, and there were but a few seconds left. The pilot shouted to his companion to act; pleaded; then in a frenzy shouted and shouted again. But to no purpose. The other sat rigid, staring into space. When there was but little hope even of saving himself, so low had they fallen, the pilot dived. He landed safely, with the dread knowledge that his friend had crashed to death in the machine.

A similar tragedy almost befell Sergeant-Pilot Hudson and Leading-Aircraftsman Molyneux, both of the R.A.F. Bombing Squadron.

They were flying at Heacham, in Norfolk, in a Fairey aircraft, when the right wing cracked, and instead of breaking off and floating away, folded back on to the fuselage. Immediately the plane began to spin and fall. Abandonment was inevitable, but when the pilot turned and gave his observer the warning to jump, to

his dismay he found that the fractured wing had imprisoned the other in his seat.

The spin was every moment increasing, their altitude every valuable moment decreasing. Hudson turned to his companion, and whilst the plane now settled into a dive, got to work to free him from the obstruction.

They had fallen a great distance, and the anxious watchers below were thinking that the jump would be made too late, when they saw Molyneux tumble out and his parachute open.

But Hudson? Why did he not jump? Was he, after releasing his observer, himself entangled? Then he was seen to leap, but no parachute fluttered out above him. The plane, now spiralling again, was cutting across his line of descent and he dare not open yet. He was falling at the rate of 119 m.p.h., the terminal velocity of a human body through the air, and if he delayed much longer he was doomed. The onlookers would have turned away their eyes, but were fascinated by the horror of the thing. There were only 300 feet more, now 200, 150, 100 feet, and still he did not pull. Not till the picture of a shattered body lying there before them had formed in their minds did the watchers see Hudson release his chute. It opened immediately and

introduced the airman to a couple of astounded cottagers by way of their back garden.

A Lady Caterpillar

Mrs. Irene Macfarlane had worked devotedly on a new design parachute of which the canopy was cotton instead of the regulation silk. Her labours were at last completed, and now her one desire was to prove its efficiency to the world. For this purpose it was necessary to arrange for a demonstration before some representative body. She had not much difficulty in this, for air experts are only too willing to give consideration to a parachute inventor's claims.

On the appointed day, therefore, Mrs. Macfarlane arrived on the exhibition ground, and such was her faith in her improved chute that she was determined to put it to the test herself.

But now came the difficulty. From tragic experience the authorities refused to let her jump unless she agreed to wear also an Irvin Regulation Chute in addition to her own. You see, they had seen other inventors, as courageous as this lady, jump with only their own chute-packs strapped to them, and had seen them drop from 2000 feet, frantically trying to open the chute until they had crashed to a frightful death.

No, she would not wear any chute but her own. Very well then, she should not jump. She could not lose her opportunity, so at last she consented, and it was as well she did.

She dropped out at 2000 feet, but her chute did not open, for it had caught in the landing-gear of the plane. There she hung helpless, and just as helpless was the pilot, for if he had attempted to land, he would have crushed her to death. At length she pulled on the rip-cord of her emergency chute, which, opening, freed her and carried her down to safety.

The Chief English Caterpillar

To Pilot-Officer J. Heber-Percy belongs the distinction of being Chief English Caterpillar, by reason of his having twice "borrowed time"—and that within a period of three months.

On the first occasion he was flying a Siskin 3A at Tangmere, when Flying-Officer H. S. Brake, testing a Hawker "Hornet", came into view. Here, thought Percy, was an opportunity not to be wasted, and a like thought coming to Brake, they were soon engaged in an exciting aerial combat. Each manœuvred with all the skill at his command to get into such a position that the enemy would have to capitulate.

It must be remembered that every aeroplane has its "blind spot". Certain lines of the pilot's vision are, for instance, obscured by the wings.

Brake had suddenly disappeared, and far from Percy's being master of the occasion, he was more like a boxer rushing forward and striking blindly. Instantly, therefore, he swept into a climbing turn in order once more to locate the enemy. Fatal move. There was a sharp blow beneath the craft that jolted him in his seat, and almost at once a heavy vibration was set up which rapidly increased.

All control had gone. The only thing to do was to "bail out" before the structure disintegrated and toppled in on him, or the machine got into a dizzy spin, or turned turtle. The safety-belt was released without difficulty, and over the side he dived.

Down he went head first, maybe sprawling face downward with legs apart, or already beginning the big somersault that a falling body makes in the air. He did not know. What he did know was that somewhere close by were two planes careering madly, and that at any moment he might be struck as he hurtled down.

He pulled on the ring, the chute opened, and, as if a great hand had seized him, he felt

himself strongly, but not roughly, straightened up and floating down quietly.

And now what had happened? He looked round, and then beneath him. To his great relief he saw the gleaming canopy of a chute, and his late enemy leading the way down, beneath it.

This episode, incidentally, provided one set of experts with a splendid argument to support their theories.

In all these adventures, the chute which proved such an effective lifebuoy of the air was of the manually operated type. The opposite school ardently advocate the use of the automatic design, on the ground that an airman whose arm has been injured would be unable to open his chute.

Now, when Heber-Percy made his climbing turn, Brake, who had also lost his man, coming up under him, had sighted him too late to turn away, and his starboard top-wing struck the Siskin's under-carriage and propeller.

Brake's Hornet went into a right-hand spin, and he knew at once that he had to clear out. He stood up and was immediately knocked back into the cockpit by the port-wing, which had folded over. He struggled up again, leant out, and was struck again by the folding wreckage. For a considerable time he was mixed up

with the falling debris, and although the collision had happened at 3000 feet, it was not till 600 feet that he was clear and judged it safe to " crack ".

As he came down he tried with his left hand to grasp the shroud-lines, to correct a slight oscillation, and found that he could not raise his arm. It had been broken close to the shoulder when the wing had struck him. In spite of this and several other face injuries, he landed safely, in time to watch Percy drop in, not a hundred yards away.

Blind among the Mountains

When Sergeant-Pilot H. E. Rous and Ldg. A.-C. A. Cameron, of the No. 30 Bombing Squadron, R.A.F., stationed at Mosul, set off in their Wapiti, from Kirkuk, to fly to Khurmal, they were in a happy frame of mind, for conditions were fair, and their course lay across an interesting country of forest and mountain. As they approached the mountains, they ran into mists which thickened and sent them climbing up to find a clearer atmosphere.

Instead of that, however, at 4000 feet, blindness came upon them, for they had run into thick, enveloping clouds. The pilot switched on the lights of the instrument-board and steered a compass course. Through impene-

trable fog they were dashing, peering each side and before them for some guiding mark, and finding nothing but a white wall. They glided to get under the bank of fog. It was of no avail. They climbed, and were still swallowed up by the opaque whiteness. Minute after minute the craft ploughed on, and their eyes were strained and bloodshot, and their ears drumming with the exaggerated roar of the engine.

They could not be far off the mountains. Fear came to them—fear of dashing into the precipitous face. Again the craft was sent up in a steep climb, and still they were enveloped. And now another calamity befell them. The engine that had been missing gave a splutter and faded out!

Here they were, then, at 6000 feet, engineless, and flying as blind as any bat.

Down they glided cautiously, to 5000 feet, every dark shadow in the encircling whiteness striking fiercely on their tightened nerves. Lower they dare not go. This was the moment, then. They stood up, and with a cheerio and good-luck, almost simultaneously dived out and were swallowed up by the fog.

The silence was broken by the cracks of the chutes as they opened. Then with legs crossed to guard against any obstruction, and with

faces protected, they resigned themselves. A few more seconds, and two more Caterpillars had floated into membership.

The Chief Caterpillar

One of the most famous names recorded in the Club Album is that of Colonel C. Lindbergh, of Trans-Atlantic fame. He is the Chief Caterpillar, and has paid his entrance-fee four times.

On one occasion he was flying the air-mail from Springfield to Peoria, and had set out just as dusk fell. Twenty-five miles out blindness came upon him, for to darkness was now added the dread menace of fog. A compass course was at once set and his instrument illuminated. Lindbergh was now rushing through a dense curtain of vapour which defied all efforts to distinguish through it a possible guiding point. He descended, trying to escape, but without success. A flare dropped was instantly lost in the darkness.

Then he changed his course, making for Maynard, but for the next half-hour was completely buried in fog. Presently the opacity lessened, the moon shone mistily, and the lights of a town now gleamed in the distance.

He dived until he could make out its plan,

but he could locate no landing-place. Again he changed direction, heading for the Illinois River, which would give him his bearings.

But then his sputtering engine warned him that the petrol was nearly used up, and there were only nine gallons in the reserve tank. Soon the engine fizzled out, and thinking that this was certainly the end, he slipped his flash-light into his belt and was about to jump when the engine picked up again.

At the most, he reckoned he had another ten minutes. Ten minutes in which to find a landing, or failing that, open country where his abandoned craft would crash with least danger to the inhabitants.

There were his mail-bags too. He reached for them to throw them overboard, but Fate seemed relentless that night: they were jammed and would not come up. He dropped another flare without result. A minute or two only left. He must use that time to climb, for the greater the altitude, the greater the chance of parachuting safely.

At 5000 feet the engine faltered, spat a little, and failed. This was the moment, then. Lindbergh released his safety-belt, stood up in the cockpit, and dived out into the night.

And now the fog blinded him again, his flash-light had fallen from his belt, and to

complete the horror, close by he heard the engine pick up.

Would the abandoned plane, now moving in a spiral about his line of descent, cut away his chute, or smash him to death as he hung by the silken cords, helpless and sightless?

Nothing but the black wall of fog around him and the spiralling craft dinning in his ears. One moment relief would come as the crashing craft went away, and the next, dread fill his heart as he heard and felt it returning. He crossed his legs to safeguard against falling astride wires, &c., protected his face, and waited for what might come.

A few seconds more and he had landed in a field. He sat up, and, but a short distance away, saw the headlights of a car. Imagine the surprise of the occupants, who were searching for a crashed aeroplane, when Lindbergh calmly strolled up and informed them that he had but lately landed, that the plane was his, and he too was quite interested in its whereabouts.

A search-party located it in a corn-field, about two miles away. It had missed a farm-house by inches. The mail-bags were intact.

The nerve of this chief! Within two years he had " bailed out " four times, and then had made preparations for his lone Atlantic flight.

So nonchalant are these modern adventurers

that one can imagine their taking notebook and pencil and making their notes as they drop to earth from the clouds.

One, Broadwick, who though not a Caterpillar, did as much as any man to make the club possible by designing parachutes, went up one day to test a new free-type chute. He dived out and fell upside down. Then he pulled the rip-cord, the chute cracked open, and as he drifted to earth, he actually took out a cigarette, lit it, and finished his journey puffing away quite unconcernedly.

His young daughter, Tiny, made many jumps in the days of experimental parachuting, when a ghastly death too often overtook the pioneers. After she had given, from some 3000 feet, the first demonstration to the U.S. army, she was the coolest on the ground. "Why," she said, "it is quite as easy as climbing off a chair."

One who Feared to Jump

What if an airman should not possess the qualities of a Caterpillar?

The answer is supplied by the following adventure of one who desired to impress his friends, and had therefore made arrangements to dive from a plane and come down by parachute.

On the appointed day, a large company of friends assembled to admire and applaud the daring fellow. He calmly took his seat in the plane, the pilot started, and soon they were over the upturned faces of the watchers.

The pilot then signalled his passenger to prepare to jump, and the latter crawled out cautiously on to the wing, and stood firmly grasping a strut. The word was given him to drop out, but there was he grasping the strut in a grip of steel. The pilot shouted at him to jump, but fear had frozen his heart and riveted his hands to the support. There he hung, a figure of stark fear, whilst the pilot, fearful of his machine being thrown out of control, alternately entreated and blackguarded the fellow to fall out.

Round and round they circled, prayers and curses alike unavailing. Hope had nearly deserted the pilot when there was a sudden crackle of wood, a severe swaying of the plane, and, glancing quickly to the right, he saw his man hurtling to earth with the broken strut and a piece of the wing attached, firmly tucked under his arm. A moment or so and the chute spread out and lowered safely to his friends a spectre with a broken strut and piece of wing firmly held beneath his arm!

Many are the Caterpillars who have "borrowed" but a very, very little time, and of their stories there is none more poignant than that of the famous test-pilot Hoyt.

Alone, and in the face of a sixty-mile-an-hour blizzard, he set off, in a new plane, to cross the treacherous Rockies, from Salt Lake City.

The hazards of such an adventure are sufficient to destroy completely the nerves of any man of imagination—unless that imagination be absorbed in transcendent faith. Such faith was Hoyt's. Thoughts of crumpled wings, of explosion, of being driven, blinded by snow, into a precipitous cliff—such thoughts this intrepid airman smothered ere they seized upon his mind. Into the raging storm he drove his craft, through the passes where the treacherous, freezing winds tugged at him, and the thickening snow blinded him, and ice weighted his wings and lowered his speed.

To get above the storm he went up to 13,000 feet, but there was no cessation. Ice and snow upon the ship sent him down again in a steep dive. When he attempted to level off, his controls failed. Down towards the rocky face of a gorge he plunged. He thrust open the cabin-door and leapt into the blizzard.

One! Two! Three! he counted; then pulled the rip-cord.

The lobe-chute opened and lowered him to a small snow-covered plateau.

What followed was revealed some days later when the search-party discovered his body lying beside a pile of brushwood which he was in the very act of lighting when death stayed his hand. He had laboriously worked his way down the valley, through heavy snowdrifts, in the effort to strike some woodman's hut, and, when hope had at last departed from him, had written tender words to his wife, on scraps of his notebook, and stuck them on the spikes of bushes where he had lain and rested.

PART III

The Epic of the Trans-Pacific Flight

"We were dreamers, dreaming greatly in the man-stifled town.
We yearned beyond the sky-line where the strange roads go down.
Came the Whisper, came the Vision, came the Power with the Need,
Till the Soul that is not man's soul was lent us to lead."

KIPLING.

The Vision

In 1492 Christopher Columbus, having braved the storms of the Atlantic and mutinous deeds of his crew, first sighted the West Indies and opened men's eyes to the illimitable possibilities of the New World.

Less than a hundred years later, Francis Drake, in the *Golden Hind*, seeking fresh lands, with infinite difficulty and hardship, rounded Cape Horn to sail the virgin waters of the West and explore the uncharted wastes of the Pacific.

What valiant souls were these pioneers, who, facing the unknown with brave hearts, opposing the forces of Nature, and scorning the ignorant

sneers of their fellow-men, navigated their frail craft with indomitable perseverance!

Truly heroic ages those, yet no more so than our own time, when men may still be found who, with an abiding courage, will brave the heart of the cyclone, forcing their way through the trackless air to the haven of their choice.

Drake and Columbus and their fellow-voyagers had to adventure forth in absurdly small ships inadequately equipped and sadly lacking in navigating instruments of precision. In these circumstances it was to their advantage that they were in search of new lands, rather than particular ports where the making of a good landfall would need accurate navigation.

The story we now have to tell is of an adventure that may well rank with the great voyages of the world. It is the epic flight of Kingsford-Smith and his three brave companions across the wide Pacific from Oakland in California to Brisbane in Australia, through 7000 miles of storm and sunshine, night and day, and all the chances of this uncharted air. 7000 miles in a flying time of 83 hours and 11 minutes.

It is not only the story of a great flight, but of an endless struggle to overcome difficulties that were only solved to be replaced by others equally trying.

The story begins in Australia, where, for six years, unknown to each other, two men dreamed the same dream and held the same high hope of emulating the pioneers of other days by blazing the first air trail across the Pacific. These two were C. E. Kingsford-Smith (since honoured by knighthood) and C. T. P. Ulm. As early as 1921 they actually met for a few minutes at Mascot Aerodrome, near Sydney, and parted without learning of their common hope.

Six years later, being employed in the service of the same air transport firm, they met again, and discovered that they cherished the same aim, and resolved to join forces until that aim should be accomplished.

Early Plans

Money was the great need for such an adventure, and their first labour, as far back as 1918, had been to strive to obtain the necessary financial support. This proved an extremely difficult task, for in those days the world looked askance at the mere mention of the possibility of such flights, regarding them as flights of fancy or even symptoms of madness. To persuade anyone to supply money for the furtherance of such a venture seemed well-nigh hopeless, and indeed through the long years of their preparation this perpetual struggle

for money was to prove one of their most serious obstacles.

To attract and give proof of their flying ability they planned an "All round Australia Flight" to break the previous record of twenty-two days eleven hours for that course. The story of their struggle to obtain enough money to begin even this relatively small venture, and of the many and striking adventures that befell them before they succeeded in lowering the record to ten days for the 7500 miles, would make most interesting reading had we the space to record it.

Suffice it to say that their publicity campaign bore fruit, and they received many promises of support, including a guarantee of three thousand five hundred pounds from the Government of New South Wales.

Very soon after this the two pioneers, together with Mr. Keith Anderson as an additional pilot, set sail for San Francisco. On their arrival in America they found the country in a fever of excitement over the Dole Race, which was due to be held in three or four days' time. This contest was for an award for the first flight from San Francisco to Honolulu in the Hawaiian Islands, a distance of 2400 miles. The new arrivals were, by the good offices of the Vacuum Oil Company, offered the option

of a plane if they wished to compete. In the short time at his disposal, Kingsford-Smith, with that thoroughness and attention to detail which is one of the most striking traits of his character, made a most careful study of the plans and machines of the competition. He concluded that for the most part the equipment did not offer much chance of success for the "hop" to Honolulu, let alone the long run to Australia, and he declined to take part.

The Dole Race took place and unfortunately resulted in the loss of several gallant lives, including that of one woman. Kingsford-Smith was not greatly surprised, as he had already foretold the possibility of such losses, in a cable to Australia.

Two new aspects of flying were clearly brought into the light as a consequence of this event—blind flying and excessive overloading. By blind flying is meant the ability to pilot a machine from an enclosed cockpit, having no view whatsoever of the outside world, but relying entirely on the indications of the various instruments that are fitted to enable this to be done.. Blind flying is essential for the covering of great distances requiring travel by night, or under conditions of bad visibility.

Excessive overloading has to a very large extent been unavoidable in long-distance record-

breaking flights, since to travel those very distances great loads of petrol are required, which make the machine so heavy at the start that the take-off is fraught with great danger, and for some hundreds of miles the plane is not so controllable as might be wished.

Into these problems Ulm and Kingsford-Smith plunged with ardour, and furthermore they set to work to make an exhaustive study of many previous long-distance flights. It did not matter to them whether the flights had failed or succeeded. In either case they sought for the main causes of failure or success that they might profit thereby.

In a very large measure Kingsford-Smith's outstanding flying successes have been due to this careful research that has always preceded any of his undertakings.

Nothing has been too small for his attention, and as far as is humanly possible he has omitted no precaution that would lead to safety and success. However, let it not be thought that his attitude was "Safety First" for his own sake. A leader of such expeditions is responsible for the lives of his companions, and indeed Kingsford-Smith's achievements may be put down to the use of brains coupled with great personal courage.

Arising from the investigations previous to

E 528

KINGSFORD-SMITH AND THE "SOUTHERN CROSS"

Facing p. 104

the Pacific flight, a number of facts emerged that were fully used when the attempt was made.

The vital need in such an enterprise is a powerful and reliable engine, one that will deliver its output hour after hour without a falter until port is reached. If to this feature can be added that of low fuel consumption, then comes success in sight. It was found at that period that time after time one engine in particular had been in a high degree responsible for many record-breaking successes. This was the Wright "Whirlwind", and so they selected the 220 h.p. radial J5C for the flight.

Since one of the " hops " would entail a flight of over 3000 miles, the weight of the petrol would be considerable, which brings us to the next most important need—a good weight-lifting plane.

Once more the results of their analysis came to their aid, and they chose a Fokker high-wing monoplane, as did Sir Hubert Wilkins for his Arctic explorations.

Commander Byrd had used a three-engined Fokker for his North Polar Flight, while a similar machine piloted by Maitland and Hegenberger had made the first flight from San Francisco to Honolulu. Kingsford-Smith was strongly of the opinion that had the Dole

flyers used three-engined planes there would have been few casualties, and therefore when his own turn came he intended to use a tri-motored craft.

That he would now be able to add to his crew was another point in favour of the large machine. In addition to two pilots there would be room for a navigator and a wireless operator, two men whose services would be invaluable.

Mention has already been made of the advantage that lay with Columbus and Drake, who had no definite port to make: consider the extraordinary difficulty that awaited these new Argonauts of the Pacific!

Do you realize the magnitude of the task entrusted to their navigator? More than two thousand miles of sea to cross on the first stage before they reach—what? A small group of islands. On again, over the endless waste of water, for a still greater leap of over three thousand one hundred miles, to hit just the one small spot of Suva in Fiji. No wonder an American observer called it "making a long shot at a dot on the map".

So it was that the forethought of Kingsford-Smith provided the assistance of a skilful navigator, who might devote the whole of his time to this all-important work.

All the improvements in navigating instru-

ments, and skill in handling them, that have been made in the last four hundred years would be needed to bring this flight to a successful issue.

The "Southern Cross"

The translation of thought into deed is usually a long process, and our heroes found their path beset with obstacles. They had, however, one stroke of good fortune, for at the very time that they were seeking a Fokker, there came, quite unexpectedly, a telegram from Sir H. Wilkins offering them a plane of that type for which he had no further use. True, it was without engines or instruments, but otherwise the craft was in excellent condition, and the price asked, about £3000, was within their means. The offer was finally accepted, but the difficulty of money arose again. There was not enough in hand to buy plane and engines. Again and again during the time of preparation, ample proof was given that there are a number of extremely generous people in the world.

Now Sir H. Wilkins was to confirm this by allowing them to postpone the payment of half the purchase price. This put them in a position to give an order for the Wright "Whirlwinds". It was one thing to give an order, but quite another to get delivery. The Wright Company

were about ninety engines behind at their works, and the thought of waiting till all those engines were completed was appalling.

What could be done? Application for assistance was made to the British Ambassador at Washington, and the Australian Commissioner at New York. It was suggested that these gentlemen should see if it were possible for the United States military authorities to allow three engines, forming a part of their order, to be released on a promise of Kingsford-Smith to place an order with the Wright firm for another three. The permission was kindly given.

The co-pilots received another wonderful example of generosity on meeting an Australian business man—a Mr. Myer—to whom they applied for financial assistance. He did not like the idea of being in any way responsible for sending them to what he considered to be certain death. Seeing, however, that they were determined on their course, he gave them £1500 and would not hear of any mention of a return of this sum.

The Dole disaster was viewed with consternation throughout the world, and ill-instructed opinion held all such flights to be extremely hazardous, if not impossible. Influenced by these views, Mr. Myer shortly wrote to his friends urging them to give up the

flight, and at the same time assuring them that the money was a personal gift that he wished them to keep, since its acceptance was in no way contingent upon the performance of the flight. A truly generous action that, taken in conjunction with others they experienced, should go far to show that faith in the goodness of mankind is not misplaced.

Further instances of most handsome treatment can be read in that absorbingly interesting book *The Great Trans-Pacific Flight*, by Air-Commodore C. E. Kingsford-Smith and C. T. P. Ulm, to which we are indebted for much of our information.

To return to the story. Fate now proceeded to deal such a series of hammer-blows that, falling on men cast in a less heroic mould, would have ended all thoughts of any further attempts at the flight. A number of their Australian supporters requested them to give up the project. Fears induced by the Dole Race were influencing opinion in the Great South Land, and many were the letters received condemning their project. Then came the telegram from the Government requiring the abandonment of the flight.

They "Kept on keeping on", to use their own phrase.

Yet another blow. A new Government

elected in New South Wales declined to advance or guarantee any further money. Add to this, Sir H. Wilkins now needed the balance of their purchase money to help forward his own Polar expedition.

To crown their misfortunes came a telegram from the new Government, ordering the abandonment of the flight and the sale of the plane.

Could Fate have been more unkind to these dauntless men?

Yet the darkest hour ever precedes the dawn, and though they knew it not, the sun of a glorious day was about to rise upon them.

While making unfruitful attempts to sell the plane at such a price as would enable them to meet their obligations, they were introduced to a man to whose munificence too high praise could not be given.

Capt. G. Allan Hancock, a wealthy Californian ranch-owner, was, as a skilled navigator, extremely interested in their plans. He invited them to be his guests on a cruise down the Pacific coast in his yacht.

During this trip, after having considered the whole question, he offered to buy the plane and enable them to fulfil their original plan.

Now at last the way seemed clear for the completion of the final preparations, and they set about them with a will.

Final Preparations

While the earlier struggles were going on Kingsford-Smith, acting on his usual plan of leaving nothing to chance, arranged for Keith Anderson to go to the Sandwich Islands to decide whether Wheeler Field, Honolulu, or Barking Sands was more suitable as an aerodrome.

On his return he reported that Wheeler Field was a good landing-ground, but that Barking Sands would be more suitable for the take-off of a heavily overloaded plane.

After much careful consideration it was decided that the journey should be made in three stages. The first, one of 2400 miles, was from San Francisco to Honolulu. The second, the longest and most difficult, was the 3128 miles from Honolulu to Suva in Fiji. From Suva to Brisbane in Queensland was the final run of 1508 miles.

Now ensued a period of intense activity for all concerned in the great flight. A thousand and one details demanding instant attention came crowding in upon them.

Stores, equipment, petrol and oil supplies, instruments, radio navigation arrangements, tests and overhauls, all required thought. In addition, time must be found for flying practice

under, as far as might be, the arduous conditions likely to be encountered on the passage through the unexplored equatorial air.

Blind Flying

Mention has already been made of the new aspects of blind flying, and the take-off and operation of heavily overloaded aeroplanes. The consideration of these two factors in greater detail is now advisable.

Assuming a ground speed of 90 m.p.h., the time for the shortest "hop" would be about twenty-seven hours, while the longest would occupy about thirty-five hours. Thus it will be seen that on each stage, whatever hour might be chosen for the start, at least one whole night must be passed speeding onward through the darkness of the unstable air. Also, be it noted, in tropical regions the period of darkness is rarely much less than twelve hours.

Again, in 7000 miles of ocean flying, large masses of dense cloud must be expected, lying at such altitude that, for reasons of petrol economy, the flight must be through them, instead of less dangerously above.

Here, then, were sufficient reasons for the need of skill in "blind flying", and so Ulm and Kingsford-Smith devoted many hours to gaining perfection in the new art.

The instruments on which dependence must be chiefly placed are the compass, air-speed indicator, altimeter, and turn-and-bank indicator. As might be guessed from its name, the altimeter is used to give an indication of height. Actually it is a sensitive aneroid barometer, making use of the fact that the pressure of the air falls as the height above the earth increases. Considered as an aircraft height-recorder, the instrument suffers from two disadvantages.

In a flight of any considerable duration, it is extremely unlikely that the air pressure over the surface of the country flown would remain unchanged. Any change would produce a zero error in the instrument reading, which could not be corrected unless the amount of the change were communicated to the pilot in some way.

A second and more serious fault lies in the fact that the instrument records height only with reference to the starting-point of the flight when the zero of the instrument was adjusted. Thus, during flight over rising land, the altimeter will give no indication that owing to this cause the machine may be getting dangerously close to the ground.

Since the time of the Pacific flight a new type of instrument has been invented, and is undergoing trials which will give actual indication of how far the earth is below the machine.

In trans-oceanic flights, this second error is obviously of not much account.

The turn-and-bank indicator is designed to acquaint the pilot of the "attitude" of his craft relative to his chosen flight-path. It functions by virtue of a small gyroscope which is arranged to show instantly any change of attitude.

It should now be clear that the pilot has plenty to do in blind flying with so many instruments to watch, for, naturally, in addition to those already mentioned, all those relating to the engines, such as revolution counters, thermometers, oil- and fuel-gauges, need continual attention.

The most difficult feature of blind flying has yet to be mentioned. This is a psychological one. Put simply it is "your instruments are always right". Whatever your senses may tell you about the conduct of the plane, unless the information agrees with what the instruments record your senses are wrong, and must not be allowed to influence the control of the flight. Since we have spent most of the years of our life in training our senses, and relying more and more on their accuracy, this is indeed a hard lesson to unlearn.

To men of the stamp of Ulm and Kingsford-Smith difficulties are only incentives for further

effort. Needless to say, they mastered blind flying.

The flying of a heavily overloaded plane was the next problem that engaged their attention. The method of attack was consistent with the forethought and application that had marked their earlier procedure, and now they embarked on a series of what they described as " building-up tests ".

Estimating what would be the greatest load required to be carried for the longest stage, they began by practising flight with 60% of this value. Then in steady steps they increased the load to 70%, 80%, 90%, 95%, 100%, and finally 110%. The value of these tests was fully proved, as it was found necessary as a result to carry out several structural alterations to the plane, to increase its strength and improve its performance.

Feats of outstanding merit are not the result of chance. More than mere luck is needed to provide a great success, and this venture of Kingsford-Smith and his companions gives point to the argument.

What an amount of preparation and forethought went to the organization of this flight!

Mere duplication of ways and means was not enough: where possible they had three or even four strings to their bow.

First the plane with its three engines. Should one of these fail the remaining two would keep the craft in flight, and in the rare event of two stopping together the third would enable a slow rate of descent to be maintained, thereby allowing a great choice of landing-places.

To ensure the maintenance of direction, no less than four compasses were taken, including the highly sensitive and very expensive earth-inductor type. This latter is in effect a small dynamo, energized by the earth's magnetic field, and generating a current varying in strength with the machine's attitude to the magnetic meridian.

In navigation again little was left to chance. To fix the position of the plane from time to time its latitude and longitude would, as at sea, if the sun were visible, be determined with the aid of sextant and chronometer.

As a check, radio direction-finding could be used as explained in the chapter "Sign-posts of the Air", the aerodromes being replaced by ships whose positions were already known.

Although four compasses assisted in maintaining direction, further help would be available from ingenious radio-beacons in operation at San Francisco and Honolulu. A short account

of the method of working these might be of interest.

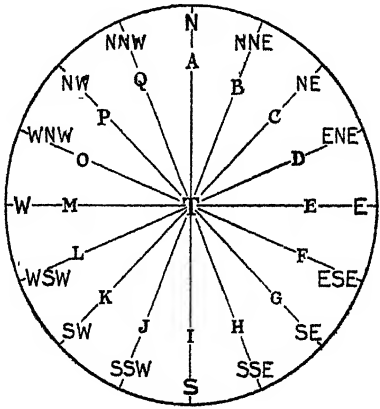
The beam of light that sweeps round the horizon from the lantern of a lighthouse is produced by a revolving system of lenses, which concentrate the rays from the lamp into an almost parallel beam. A similar beam might be projected by a revolving reflector placed behind the light instead of the lens system surrounding it. Short radio waves can, in a similar manner, be transmitted in a beam by specially designed reflectors behind the transmitter. Such reflection on a fairly large scale can be seen in England at the Marconi Beam Stations at Dorchester, Bodmin, and Bridgewater. In these cases the reflecting system consists of a number of vertical wires, permanently fixed so as to throw the signals towards the receiving stations.

By using quite short waves the reflector may be made small enough to be rotated at a regular speed. By adding one further feature to the system it becomes a radio-beacon. The diagram on the following page will simplify the explanation of the additional feature.

As the rotating beam passes through the various points of the compass it transmits a definite letter denoting that point.

For example, when D is transmitted the

beam is ENE from transmitter T, and similarly K would denote SW. Thus it will be seen that on hearing in the telephones a certain letter you would know that you were on the appropriate bearing from T. Should the wrong



letter be heard, you are off your course and must steer until it is picked up.

It is scarcely necessary to add any further example to illustrate the thoroughness of the preparations for this flight, although many others might be given, such as those concerned with lessening the dangers of a forced landing.

When the time for the start drew near, an invitation was sent to Keith Anderson, who was in Australia again. It was, however, impossible for him to return at that time, and new members for the expedition had to be sought. Fortunately the services of two Americans, Harry Lyon and Jim Warner, were secured. These two men proved to be most efficient helpers and ideal companions for a venture of this kind. Lyon was an expert navigator, and Warner a most competent radio-operator.

At last, all the trials and troubles of preparation being over, came the great day—31st May, 1928—when, sweeping up into the air of the Pacific, they were to put their fortunes to the test.

The First Stage

The First Day

"While men depart, of joyful heart
Adventure for to know
(As now we witness here)."

KIPLING.

What courageous hearts had these modern Argonauts, who on this May morning, in their Lilliputian craft, dared to face the immensity of the Pacific, well knowing that, should their vessel fail, two thousand miles of empty sea were waiting to engulf them.

Just before 9 a.m. on this memorable day,

with the rhythmic roar that augured well for the future, the three Wright "Whirlwinds" drove the *Southern Cross* into the Oakland air. In the cockpit were the pilots, Kingsford-Smith and Ulm, separated by a bulkhead from Lyon and Warner in the navigating cabin. So great was the noise of the engines that conversation was impossible, and communication was made by pencilled notes passed on the end of a stick through a hole in the partition.

A thousand feet below, the streets of San Francisco are sliding back, and ahead is the misty sea—the first stage of the long trail to Australia. At ninety miles an hour only a few minutes pass before the mainland of America, where hope and despair have alternately cheered and mocked them, disappears in the haze.

Like a brown smudge on the horizon ahead lie the Farrallone Islands, the last land to be seen for two thousand miles. In less than half an hour out from San Francisco these in their turn are swept astern.

"Departure" has been made, and Warner, phones on ears, reports that they are right on the T beam of the San Francisco radio-beacon. The regular music of the engines is good hearing, and Lyon tells the world that all is well.

How does the time pass on the *Southern Cross*? The pilots have no regular hours of

duty, but take turns at the controls as they think fit. Lack of space prevents their lying down at full length, and relief from cramp can be obtained only by stretching themselves as far as possible. The cabin crew are more fortunate, and when not on duty can, if they wish, snatch such sleep as the noise of the engines will allow.

The pilot's duties entail constant alertness, for, although risk of collision with other craft is absent, yet there remains the work of keeping the ship on its course at an altitude judged to be suitable to the conditions at the moment. The lower the level at which flight can be maintained, the less petrol will be used.

Climbing to heights burns up the precious fuel at an extravagant rate. On the other hand, to fly too low was to court being driven to the sea by a sudden downward current. In the early stages of the " hop ", since the plane was badly overloaded, it was in such a condition that a relatively slight downward current might be enough to cause disaster. It was decided that in favourable weather an altitude of about one thousand feet should be kept during the daylight hours. With the approach of night, however, it was thought advisable to climb to the region of five thousand feet, to give a greater margin of safety, as the coming of a

squall, usually heralded by a cloud formation, would, in the darkness, be unobserved.

Time does not hang heavily in the navigating cabin, where there is much to be done. Warner is keeping in touch with the shore stations at San Francisco and Honolulu. From time to time he has reports of progress to make to the outer world. In addition, a "lookout" has to be kept for the radio of a few ships that are thought to be somewhere near the course. To check the beam of the radio-beacon and report to the navigator and pilot, should they stray from the correct zone, is another of the radio-operator's duties.

Lyon also has quite enough to do with his observations and calculations. He must, now and then, work out the ship's position and compare the results, as determined by dead-reckoning or astronomical observation, when the sun is visible.

"Dead-reckoning" is a rather unhappy expression which denotes the calculation of a position with reference to a previous known position by means of the compass course and an estimate of the number of miles covered. The French expression "le point estimé" is a much better description. In the *Southern Cross* the distance run was calculated from the time taken and the rate shown by the air-speed indicator,

after correction had been made for "drift"

Determination of latitude and longitude by use of a sextant involves the altitude of some heavenly body with reference to the horizon. Now, unfortunately, the higher one goes above the surface of the earth, the more indeterminate, as a result of haze, does the horizon become, and resort has to be made to some form of artificial horizon. The type of instrument used by Lyon was that known as the bubble sextant. In this the horizontal position is found by a spirit-level. Such an instrument requires most skilful handling, as the angular distance has to be measured by means of two moving objects —the sun and the bubble.

Boredom would seem less likely to visit the cabin party than the pilots.

When all was going well as they swept over the empty ocean, incidents to attract their attention were rare, and their minds were free to explore all kinds of possibilities as to the future of the flight.

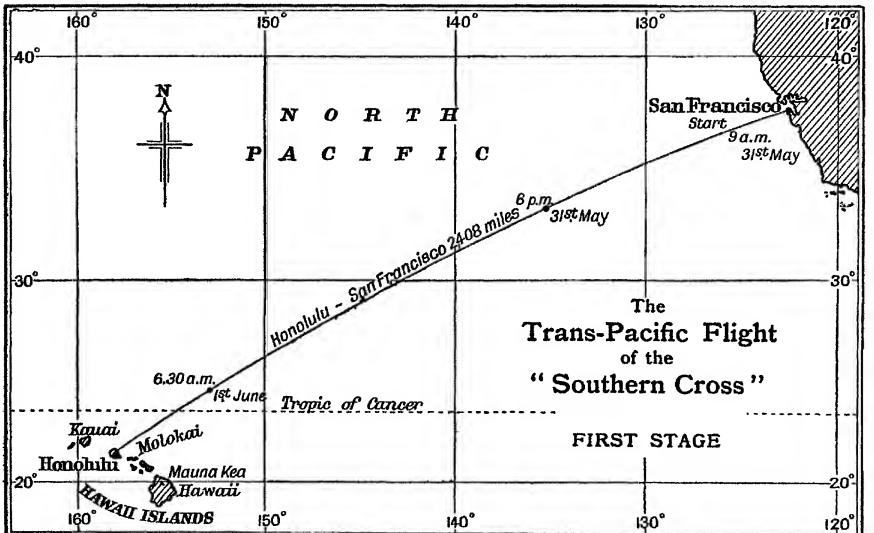
One of these conjectures was as to the rate at which the fuel was being consumed on the actual flight, and not under experimental conditions which they had already experienced. Communicating their doubts and fears, each made an estimate of the quantity of the precious fluid that remained in the tanks.

To give sufficient storage capacity to cover the longest "hop" of 3128 miles, the original tank arrangements of the Fokker had been altered, and there was now room for 1298 U.S.A. gallons.[1] This quantity was distributed among six tanks, four in the wings, one under the pilot's seat, and the main one in the fuselage.

The estimates differed rather widely, as Ulm considered that only two hundred and ninety gallons were consumed, while Kingsford-Smith was of the opinion that as much as four hundred gallons had been burnt. To put the matter to the test it was agreed to run the engines on the outer wing tanks until that supply should be exhausted, when a clear indication would be given as to the amount remaining.

Before they left San Francisco, weather reports had forecast favourable conditions as far as Honolulu, and the forecast proved correct. In the early afternoon the first stretch of blind flying was experienced, when the machine, after climbing to nearly 3000 feet, was compelled to enter a cloud bank that extended for 20 or 30 miles. If you have ever driven a car in a thick fog, you will realize the helpless feeling that follows loss of sense of direction. In a plane you seem to be roaring through a tunnel whose walls are pressing in upon you. Now

[1] A U.S.A. gallon = ·883 English gallon.


160°
150°
140°
130°
120°
40°
30°
20°
N
NORTH
PACIFIC
San Francisco
Start
9 a.m.
31st May
8 p.m.
31st May
Honolulu - San Francisco 2408 miles
6.30 a.m.
1st June
Tropic of Cancer
Kauai
Molokai
Honolulu
Mauna Kea
Hawaii
HAWAII ISLANDS
The
Trans-Pacific Flight
of the
"Southern Cross"
FIRST STAGE

it was that the practice in blind flying began to stand them in good stead. After about twenty minutes of this trying work they emerged into clear air once more.

The afternoon wore on, and it was just before 5 p.m. that the decision to run on the outer wing tanks was made. In another hour Lyon was able to take a "sight" on the westering sun. From his calculations he found that the position then, at 6 p.m., was latitude 33° N., longitude 135° W. Eight hundred and six miles had been covered, and there still lay 1602 miles between them and Honolulu.

As the daylight waned they began their climb to higher altitudes, keeping the dying light a little longer, and enjoying the most wonderful sunset.

> "... We saw the Sun retire,
> And burn the threshold of the night,
> Fall from his Ocean-lane of fire
> And sleep beneath his pillar'd light." [1]

With the coming of darkness the petrol in the wing tanks was exhausted, and to their great relief Kingsford-Smith's pessimistic estimate was proved false.

Picture them, then, roaring on through the blackness, void of light except for the glimmer of a thousand stars. Flames of changing colour

[1] Tennyson.

spurted from the exhaust-pipes, and had there been a watcher on that sea, he would have noted their passage like a fiery rocket across the night sky.

As the hours passed the moon rose, spreading a silvery track on the waters across which they sped.

> " New stars all night above the brim
> Of waters lightened into view;
> They climbed as quickly, for the rim
> Changed every moment as we flew.
> Far fan the naked moon across
> The houseless ocean's heaving field,
> Or flying shone, the silver boss
> Of her own halo's dusky shield." [1]

During the hours of darkness it was advisable to check the drift, so at 10 p.m. water-light flares were cast into the sea, where they remained burning brightly, enabling the drift-meter to be operated. The result showed that drift was practically absent.

So well did the flares show up that they were still visible at a distance of twenty-five miles.

Shortly before midnight the weather changed, heavy clouds were encountered, and the flying was blind for a quarter of an hour during which the rain poured down.

At midnight the altitude was 5400 feet, and

[1] Tennyson.

the speed on the climb had fallen to 77 m.p.h.

Now, in all the fifteen hours of flight, although various vessels were reported to be near their track, there had been no sign of any craft. Therefore it was a noteworthy event that the lights of a steamer were observed on the port bow at ten minutes to two. Ulm flew round the steamer, while Kingsford-Smith signalled with searchlight by Morse and was answered.

To add further to their excitement, they had in less then three-quarters of an hour also sighted and "spoken" the S.S. *Manoa*.

So the long night passed with varying weather, but on the whole favourable conditions, amid moonlit cloud-scenes of unbelievable beauty.

The hour before the dawn is ever the coldest, and now the keen, cool rush of the air whipped the blood to the faces of the pilots in the cockpit, as they drove over the curve of the world into the dawn of a new day.

The Second Day

To all who have passed the long hours of night in the solitude of great spaces, under the arching sky, has come at times an overwhelming sense of the utter insignificance of man—a dread feeling of the menace of the forces of nature.

To such the dawn is ever welcome; it lifts the clouds of fear and heartens the soul of man to take up a day of new endeavour. Well can we imagine the joy with which our heroes greeted the coming of daybreak in the eastern sky. Whatever the future might have in store, they had already, with the precision of a train on its track, held their course for nearly two thousand miles. Came also a deep sense of gratitude to those faithful engines that for over twenty hours, with wonderful regularity, without even a single misfire, had driven them ever on across the waste of waters.

Rather jaded must the crew have been after their long spell of work, but now the light is broadening fast, and, as the Psalmist says, "joy cometh in the morning".

By 6.30 a.m. Lyon has calculated their position, and gives the good news that they are within 375 miles of Honolulu.

All is going well. The months of careful preparation are bearing fruit, and a few more hours should see the successful close of the first stage.

As time passes, excitement grows. Straining eyes keep an eager watch ahead. Who will be fortunate enough to have the first glimpse of land—the first sight of a dot on the map?

Time and again low lying masses of cloud

deceive tired eyes, and what appears to be solid earth, on closer acquaintance, reveals its true nature.

A little before eleven o'clock their vigil is rewarded, for, piercing the clouds on the port bow, rises the snow-covered summit of the 13,000-foot peak of Mauna Kea. Surely the moment is comparable with that when Columbus first gazed on the coast of Watling Island.

Away on the port bow there now rises the long line of precipitous cliffs that forms the northern coast of Molokai—a place of heart-rending associations and lives of incredible heroism.

Molokai was the scene of the labours and the tragic yet noble death of Father Damien. Fifty years ago that great-hearted Belgian priest and missionary, well knowing the terrible end that awaited him, voluntarily went to that leper colony to give its poor outcasts ungrudging service, both spiritual and material, until such a time as he himself should fall a victim to the dread scourge of leprosy. Of his action, Robert Louis Stevenson, the famous author, who had himself stayed in the colony, said he was "shutting to with his own hand the door of his own sepulchre".

Doubtless the crew of the *Southern Cross* viewed with deep respect this silent witness to human heroism in another form.

Having got their bearings, they plunge downwards through a sea of fog, below which lies clear air and the sea. Sweeping onward towards their port, the coastline is crossed, while beneath them are the crowded streets of Honolulu, filled with madly cheering people. Only another 20 miles remain, and at 12.17 p.m. on 1st June they come safely to earth on the aerodrome of Wheeler Field, having travelled 2408 miles in 27 hours 25 minutes.

A great reception awaits them, but what they chiefly need is sleep, for they wish to waste no time in getting on with the 5000 miles that still lie before them.

The Third Day

Early the next morning they were back from Honolulu at Wheeler Field, where United States military and naval mechanics had spent the night in overhauling the *Southern Cross* and its engines. From a check on the remaining petrol it was found that the consumption had worked out at a little more than thirty-five gallons per hour.

In the afternoon, with a light load of only seven hundred gallons of fuel, the machine was flown to Barking Sands, the chosen take-off ground on the island of Kauai, a distance of about 90 miles.

Arrived there, a further supply of petrol was taken on board, charging the tanks to their full capacity of 1300 U.S.A. gallons. A fearsome load to be lifted on the morrow, and one that would require all the pilot's skill to get away with safely.

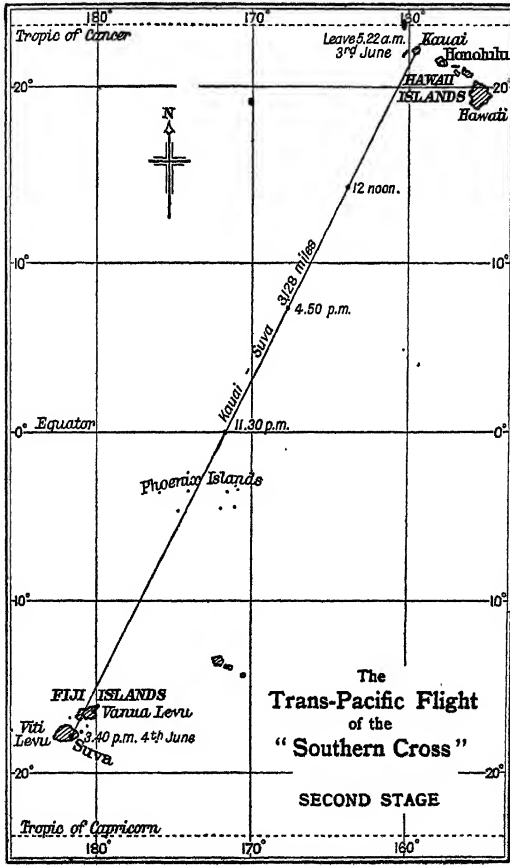
The Second Stage

Barking Sands to Suva

Well before dawn on 3rd June the party were on their way to Barking Sands. By a quarter-past five they were all in their places and ready to drive on into the warm moist air of the tropical Pacific. So great was the load of petrol—three and a half tons—that it had been estimated that a run of nearly three-fifths of a mile would be required to gain sufficient speed to take-off with safety. To assist the pilot, one of the helpers was stationed 3500 feet down the sands, as a mark.

At 5.22 a.m. the second "hop" began, and after a run of 3400 feet the *Southern Cross* took the air and slowly climbed to an altitude of 350 feet in eight minutes. Only superb piloting saved the craft from disaster from a number of bumps that were encountered on leaving the coast.

Now was to come the supreme test. The


180°
170°
160°
Tropic of Cancer
Leave 5.22 a.m. 3rd June
Kauai
Honolulu
HAWAII ISLANDS
Hawaii
20°
N
12 noon.
10°
3128 miles
4.50 p.m.
Kauai - Suva
0° Equator
11.30 p.m.
Phoenix Islands
FIJI ISLANDS
Vanua Levu
Viti Levu
3.40 p.m. 4th June
Suva
The
Trans-Pacific Flight
of the
"Southern Cross"
SECOND STAGE
Tropic of Capricorn

immense waste of waters must be covered with such precision that after 3000 miles at sea the error in navigation must not amount to much more than fifty miles if port were to be reached.

The importance of navigation on such a flight cannot be overestimated; indeed, it has been said that for every navigator capable of keeping the course over a long ocean flight there are fifty aviators who could manage the piloting. Be this as it may, the highest praise is due to Harry Lyon for the almost miraculous way in which he guided the pilots of the *Southern Cross*.

To conserve the petrol as much as possible in this difficult stage it was agreed to keep to as low an altitude as possible, and in the early hours 650 feet was the height chosen.

The splendid way in which everything had worked on the opening stage caused the first set-back to be felt more keenly.

Not long after leaving Kauai the low-tension generator of the wireless installation failed: they were left without any means of communication with the lower world. Although their faith was profound in Warner's ability to repair most defects that might arise, yet the feeling of complete isolation resulting from the failure tended to damp their high spirits. Loss of radio deprived Lyon of the reassuring buzz of

the radio-beacon, and furthermore occasional cheering chats with the world they left behind were no longer possible.

Faith in Warner was not misplaced, for in ten minutes he had rectified the short circuit in the battery-charging dynamo.

About 7 a.m. the pilots received a severe shock—a clear liquid was noticed dripping from the wing tank! Visions of loss of petrol and, still worse, of devastating fire passed vividly before them.

Investigation was carried out at once. Great was their relief to find that the offending liquid was just water produced by condensation.

Shortly after this the aperiodic compass went out of action for some time. The second stage did not seem to be lacking in incident! The weather was very gloomy, threatening clouds reared up ahead, but since the risk of flying blind so early in the run was not to be lightly undertaken, they flew beneath these masses.

By 8.17 a.m. the friendly radio-beacon signals had faded out, and piloting had to be done by dead-reckoning for the time being, as there was no chance of taking a "sight" on the sun in such depressing weather conditions.

The grey miles glided astern as with engines running steadily they drove on in more and more unfavourable weather.

They were flying as low as 500 feet, when a little after ten o'clock the radio equipment again failed completely, and once more Warner was kept busy diagnosing and attempting to repair the trouble.

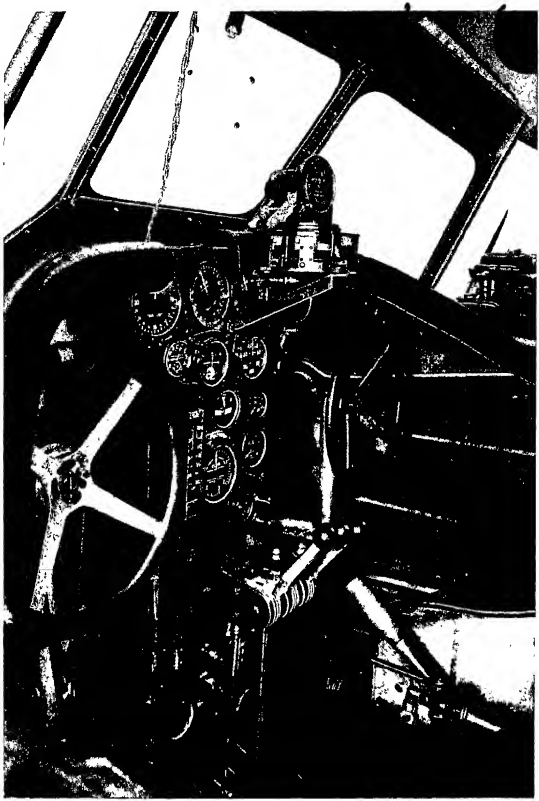
Now to add to their difficulties came the approach of heavy rainstorms that were flown round until they became so numerous that escape that way was impossible. The motors were "opened up", and with loudly roaring engines they climbed through heavy rain, and, buffeted by severe bumps, came blindly to 1000 feet, where for a time the visibility improved to about 600 feet.

Lyon was able to get a "fix" (i.e. a "sight" on the sun) shortly after noon, showing that in the seven hours since the start they had traversed 735 miles—a highly satisfactory result.

Further, soon after 1 p.m. Warner had the radio once more in operation.

Onwards, through successive rainstorms, they fought their way till a new threat of trouble filled the minds of all. For the first time one of the motors—the starboard one—ran unevenly.

So accustomed were they to the steady roar hour after hour that the slightest irregularity would be noted by startled ears. What did this change portend? Was serious trouble



THE COCKPIT OF THE "SOUTHERN CROSS", SHOWING INSTRUMENTS AND DUAL CONTROLS

Facing p. 136

impending, or was it just a symptom of a passing ailment?

For ten minutes the pilots examined the engine as far as possible, and concluded that the trouble was probably due to rain in the carburettor heaters. At any rate the engine was once more running normally, and a note to that effect was passed to the cabin occupants, who had already made inquiry.

In spite of all difficulties, by 4.50 p.m. the position was 7° 27′ N. Lat. and 167° 30′ W. Long. So they had covered 1175 miles from Barking Sands at an average ground speed of 106·5 m.p.h. A better weather outlook led them to hope for a finer night. With the waning light they began their climb to higher altitudes; but, unfortunately, the greater height brought into view fresh cloud masses that might not be surmounted at less than 5000 feet.

Ever upward they climbed, 1000 feet, 1700 feet, 2000 feet, and yet the cloud banks towered above them. Bursts of rain made them twist and turn, and still the masses became denser. Nearly an hour and a half was spent in the attempt to get above the obscuring clouds. At times they circled round and round to gain height, until after passing 6000 feet, 7000 feet, and finally 8000 feet, they found themselves above an opaque sea of cloud. But what a cost

of petrol to lift the *Southern Cross* to such a height!

Now at 8 p.m. the clearing sky was powdered with stars, as upturned eyes welcomed the glittering constellation of the Southern Cross.

With improving conditions they came down to lower levels where the air was warmer, and at 11.30 p.m. Kingsford-Smith and Ulm, crossing the Equator, came into their own hemisphere.

Just at this time another misfortune befell them when the instrument-board light failed, and the pilot had to rely on the ministrations of his partner with an electric torch.

No sign of land was seen at midnight, when they should have been passing through the Phœnix Archipelago, and a new course was set for Suva.

The long passage of the hours must have made all the party very weary, and doubtless the early hours of a new day, when man's vitality is always at its lowest ebb, found them keeping alert only with the utmost difficulty.

Just before 6 a.m. a terrific storm of rain and lightning appeared on the horizon. Its summit seemed at least 12,000 feet above the sea, and long before they reached its neighbourhood mighty bumps shook the plane.

Down and down they glided in an attempt to pass underneath its lowering mass. At 400

feet it seemed advisable to get Warner to wind in his radio aerial wire, which normally trailed out astern, like a naval "paying-off" pennant.

Speeding on, they gradually withdrew from the baleful influence of this tropical storm, and found time to compute the amount of petrol remaining in their tanks, and to estimate their chances of reaching Suva after a night of such battering blows. As before, the two pilots' estimates varied widely, and in the event the happier forecast made by Ulm again proved the more correct.

Seven a.m. found them, according to Lyon's dead-reckoning, within 810 miles of Suva.

The second dawn which greeted them above the broad Pacific was less inspiring than the first, for the growing light revealed only too clearly a mighty barrage of cloud formation, interspersed with heavy rainstorms; while below all lay the dull grey sea, the monotone of which was only relieved by the white of broken wave crests driven on by the rushing wind.

Nevertheless, if Lyon's dead-reckoning was to be trusted in any degree, they were steadily fighting their way in the teeth of the gale nearer to Suva, and the end of the longest stage.

Hour by hour the head-wind grew stronger, and the unstable air tossed the craft from side

to side, and such large quantities of valuable fuel were being used up, that once more doubts arose as to the possibility of a successful conclusion.

By 10 a.m., as a result of pumping the remaining petrol in the main tank to the gravity tank, all hands were greatly cheered by the news that there was still sufficient left for a further seven hours' flight.

As they travelled on, the *Southern Cross* came under the sway of the South-East Trade, which met it on the port bow with a speed of 35 m.p.h., causing a serious drift.

If they were much off their course, such a drift might easily exhaust the fuel before Fiji was reached.

As time went on the weather improved, clouds dispersed, the sun appeared, and consequently the navigator was able to get a "fix", and it was found that they were only slightly east of their course.

This was truly a wonderful tribute to the skill of all concerned, especially when it is remembered how, during the hours of darkness, the plane had circled round and round in the gale, and had experienced long stretches of blind flying.

As a compensation for the rigours of the past thirty hours the conditions now became charm-

ing. The air was warm, the sea turned to a mass of turquoise blue, under a glorious sun, and the hazy horizon bounded their distant view.

The great moment of landfall was eagerly awaited, and at 1.10 p.m., rising dome-like from the misty ocean, appeared Fiji about 70 miles away on the starboard bow.

A new course was set, and on they sped into the Fijian Archipelago. Welcome was the sight of land beneath them as they drove on among the islands glowing in the varying shades of verdure and soil. And now the sea changed to a beautiful green, reflecting, as it were, the tints of the vegetation, while through its clear depths could be seen the variations of light and shade and colour of the ocean-bed.

For over an hour the delight of these changing scenes rewarded the weary crew of the *Southern Cross*.

At last, at 3.40 p.m., they came in over Suva, and with a magnificent piece of piloting by Kingsford-Smith, landed in a small and extremely difficult aerodrome, to the applause of the assembled crowd, thirty-four hours and twenty-three minutes from Barking Sands in far-off Kauai.

With over 5500 miles out of the total 7000

miles safely accomplished, including the longest stage, it seemed that relatively little remained to fulfil the dream of years; yet nothing of value is ever performed easily, and once again, both in the preparations for the final flight and in its execution, arose difficulties that required courage and perseverance ere they were successfully surmounted.

The small field in which they landed with such wonderful skill was quite impossible as a "take-off" place for a heavily loaded plane. Where should they go to seek a fresh ground? Was there one near at hand? Was there one at all in the neighbourhood of Viti Levu?

Inquiry led to the suggestion that within 25 miles of Suva there were three places which might possibly fulfil the stringent conditions required. Hearsay was not enough; inspection by one of the pilots would alone satisfy the painstaking methods of Kingsford-Smith and Ulm. So Ulm went to view Nausori, a small place on the banks of a stream about 15 miles to the north-east of Suva, while Kingsford-Smith journeyed by sea to Naselai beach. So satisfactory was the latter's report on this fine stretch of sand, lying 20 miles to the east of Suva, that no longer was it necessary to inspect the beach of Navua. Unfortunately the suitability of Naselai was marred by the difficulty

of transporting nine hundred gallons of petrol by sea to the surf-beaten shore.

Ever since the time when the plan of a Trans-Pacific flight was first formulated by Kingsford-Smith, he had determined that to be of real value the passage must be made with both speed and precision.

No voyage of which it might be said that only good luck had brought it to a successful conclusion would content his passion for a "job of work" well done. We can therefore imagine what a trial it must have been to him to be kept waiting about in the island of Viti Levu while these necessary arrangements were being carried out. The party grudged every hour that must be spent on the ground, longing ardently to be moving on till they should land on Australian soil and achieve their hearts' desire.

But no start could be made until all the preparations were complete and conditions were suitable.

High tide covers most of Naselai beach, so time was wasted flying round until the ebb should lay bare sufficient sand for a safe landing, after which friendly natives brought the two and a half tons of petrol ashore in their skilfully handled surf-boats. Now the slow task of filling the fuel tanks began, and lasted so long

that all hope of departure that day faded, and the crew, with the exception of Warner, who remained on the beach to watch over the plane, spent the night off-shore on the *Pioneer*, a launch that had given them much help. The opportunity of taking an early night's rest was, however, all to the good, as it would enable the three to build up a reserve of strength for the difficult hours that still lay before them.

Warner, on shore, passed a night amid a scene of unforgettable beauty. Beyond the palms the moon rose majestically, spreading a track of rippling silver across the waters of the blue lagoon.

> "Warm perfumes like a breath from vine and tree
> Drift down the darkness. Plangent, hidden from eyes,
> Somewhere an eukaleli thrills and cries
> And stabs with pain the night's brown savagery."[1]

In such surroundings, and to the murmuring music of the distant reef, did Warner, a modern Tusitala, aided by a police interpreter, enthral the men and maids of Fiji with the wellnigh unbelievable adventures of the *Wanga Vuka* or "bird-ship" on the five-thousand-mile flight.

[1] Rupert Brooke.

The Third Stage

Fulfilment

> " When through the Gates of Stress and Strain
> Comes forth the vast Event,
> The simple, sheer, sufficing, sane
> Result of labour spent—
> They that have wrought the end
> Be neither saint nor sage,
> But men who merely did the work
> For which they drew the wage."
>
> Kipling.

Next morning, the tide being unfavourable, little was done. Shortly after midday the party from the launch came ashore, and the *Southern Cross*, her engines having been warmed up, was turned ready for the " take-off ".

At 2.52 p.m. on 8th June the final stage was auspiciously begun. So splendid was the condition of Naselai sands that a run of only a thousand yards sufficed to give flying speed.

With a wide circling sweep the beach was re-crossed, and a flight of twelve minutes brought them over the now crowded streets of Suva.

There was every indication that the fair weather which had been foretold would hold. The pleasing green of the sea and the beauty of the sky gladdened them all exceedingly. This happy state of mind received a check when the cabin party reported that the earth-inductor compass was out of order, and for two hours did

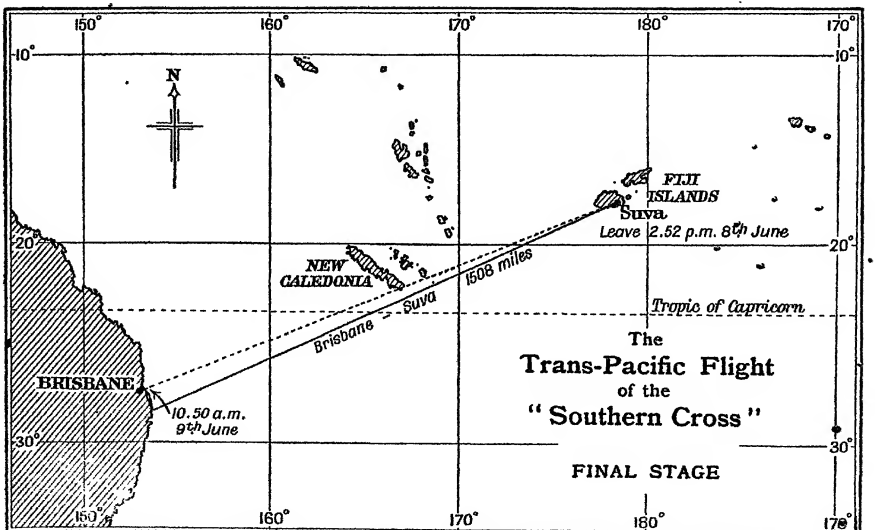
Lyon vainly try to rectify the trouble. This was indeed a serious blow, for the accuracy of this instrument far surpassed that of the other compasses which now had to be relied on for maintaining direction.

At 5 p.m. Lyon gave their position as Latitude 19° 25′ S., Longitude 175° 34′ E., showing that they were now 207 miles from Suva, having thus averaged 109 miles an hour. It was not to be expected that such a splendid rate of progress could be maintained. About six o'clock they saw the last of the sun above the horizon, and the nightly climb soon brought them to 4300 feet above the sea, which by now had turned to a steel-grey.

In a little while, with scarcely any warning, they passed out of the tropics abruptly, and a sudden fall of temperature compelled all to take to warmer clothing.

Further, the regular cross-wind changed to a series of heavy bumps that shook the plane violently. Ahead appeared rushing walls of black cloud, and then came heavy rainstorms of increasing frequency. The wind grew more violent and the plane rocked and lurched this way and that.

A short spell of clearer and quieter conditions was followed by heavier shocks and fiercer rain. Flying became blind, and to the pilot's straining


150°
160°
170°
180°
170°
10°
N
FIJI
ISLANDS
Suva.
Leave 2.52 p.m. 8th June
20°
NEW
CALEDONIA
1508 miles
Tropic of Capricorn
Brisbane – Suva
BRISBANE
10.50 a.m.
9th June
30°
The
Trans-Pacific Flight
of the
"Southern Cross"
FINAL STAGE

147

eyes it appeared as though the craft were being driven through a torrent of water. Vainly did they climb to escape these terrible conditions. Up to 9000 feet, or nearly two miles, they rose without relief. All the time the engines were eating up the fuel.

It was now they first saw the disc of the central propeller as the light of the exhaust-flames glinted on its wet surface. Normally its high speed made it invisible.

The weather grew even worse. The air seemed filled with water rushing upon them from all directions. Sudden upward currents lifted the craft hundreds of feet, and equally fierce reverse flows hurled it down a thousand feet in a few seconds.

For hours Kingsford-Smith could do nothing but endeavour to keep his vessel in the air; course-keeping was impossible, and that the crew should have lived to tell the tale is the greatest tribute that can be paid to his piloting.

During this violent time the constantly driving water had forced its way into the pilot's cockpit, gradually soaking the occupants to the skin, and chilling them to the bone. Could worse, short of actual disaster, befall them? Yes! Now it was that they noted with apprehension a flickering bluish light surrounding the leads to the plugs. Was the downpour about to be-

come too much for the insulation? Would the water cause the wonderfully efficient magnetoes to fail? Ignition breakdown on such a night as this might well end the tale. So it was the most anxious attention that the pilots gave to this new phenomenon and strove to determine its cause and its cure. They decided to keep the engines running as near full throttle as possible, since by so doing they would keep them from cooling too much, and also the sooner pass through the belt of bad weather. This course proved effective, for by midnight, without having experienced any further engine trouble, they ran into fairer conditions.

The night of trouble, however, was by no means over yet. Time and again fresh series of torrential rainstorms were met. As the plane was now less heavily loaded, several attempts were made to fly above or around these storms. So evil had the conditions been that for four hours no endeavour could be made to keep to the course, and doubtless they had been blown far from their true route.

For many hours it had been a continuous fight to get the better of the elements.

Dawn found them still driving on through a chaos of cloud above a somewhat quieter and smoother ocean flow. As ever, daylight brought its message of hope, and having passed safely

through the dangers of the night, all felt that nothing which might now lie between them and the Australian coast could cause any real hindrance to the attainment of their goal.

Happily they were no longer making a shot at a dot, but had the whole coast-line of Australia before them on which to make their landfall, and so they turned westward, confident that the sight of land must soon reward them.

Nature, having done her worst during the hours of darkness, now changed her mood, and smiled on them in their hour of triumph.

At 9.50 a.m. there appeared above the horizon the long low line of land—Australia!

They sped on above the blue ocean, coming in over the Queensland coast at a point 110 miles south of Brisbane. The new course was set, and there shortly appeared the lofty towers of Brisbane Radio Station, from which they had received messages in the dawning.

This historic flight was safely concluded at 10.50 a.m., 9th June, when the valiant Fokker came to earth at Eagle Farm Aerodrome, Brisbane, 20 hours and 58 minutes after leaving Suva.

The total time in the air from Oakland to Brisbane is given by Kingsford-Smith as 83 hours 11 minutes, making an average speed of 85 m.p.h.

PART IV

Seven Miles a Minute

The Engine

Man has always wished to move, and move ever faster. The discovery of the motive force of steam brought a great joy to him, and the coming of the railway speeded up travel. But he was not satisfied.

Since the time of the fabled Icarus, man has longed to leave the earth for the air, to exchange wheels for wings, and fly with the speed and ease of the bird.

And now he has succeeded, and can move seven times faster than the swiftest bird.

But how he has struggled to do it!

Watch him grappling with difficulty after difficulty that seemed insurmountable. Watch him groping his way out of the darkness of failure, only to be swallowed up again in the gloom, until at last he has emerged into a clearer light than has ever been known before.

What a romance, what an epic is in the story

of this conquest of speed! You are forced to a deep wonderment at the courage, the resource, the indomitable spirit of man, when he has set his hand to some great task.

More than a hundred years ago, then, engineers had successfully designed and built an aeroplane that failed to fly only because there was no engine light enough to install with any hope of success.

In more recent times, Sir Hiram Maxim, of machine-gun fame, constructed a wonderfully ingenious steam-engine, which with its boiler and condenser weighed less for its power than the petrol engine that just lifted the Wright Brothers into the air in 1903.

Unfortunately, its hunger and thirst made catering arrangements impossible.

Now it was the arrival of the internal-combustion engine (so called since the fuel is burnt actually in the cylinders of the engine and not in a separate furnace) that made the aeroplane a practical vehicle.

Thence onward the story of flight is largely the story of the production of a lighter and ever lighter engine.

Let us look at some of the milestones on the road of research.

Fifty years ago an engine that would generate one "horse-power" weighed 550 lb. If you

raise a pound weight 550 feet in a second you are working at the rate of one "horse-power" (1 h.p.).

Forty years ago the weight of such an engine had dropped to 75 lb. Motor engines now began to be used on the roads; before this they were too heavy.

Thirty years ago an engine of only 10 lb. weight was needed to supply 1 h.p. The aeroplane was in sight.

Twenty years ago the ratio of weight to power was down to 3 to 1. The aeroplane had arrived. Still the struggle went on until now in 1931 the Rolls-Royce Schneider engine weighing 1630 lb. produces about 2500 h.p. and so requires less than $\frac{2}{3}$ lb. for each horse-power. Isn't this a modern miracle?

How was the power increased without addition to the weight of the engine?

Well, it was reasoned, power is a rate of doing work. Therefore the power could be increased by either doing more work on the piston, that is, by increasing the pressure of the exploding gases, or by making the pistons move faster and so adding to the rate of working.

It seemed fairly simple to do both these things. First let us see how to add to the pressure of the piston. You know that when the piston rises in the cylinder, after sucking in the

charge of gas from the carburettor, it compresses the gas into a smaller and smaller space until it reaches the top of its stroke. In a motor-car engine cylinder the gas when compressed occupies about one-fifth of the space it did before compression, and exerts a pressure of about 70 or 80 lb. to the square inch.

When the spark from the plug fires the mixture, the pressure almost immediately jumps to somewhere near three times its previous value. The piston begins to move down with a weight of 240 lb. on each square inch of its surface.

So you see that if you want more power you may increase the compression pressure. They found two ways of doing this. The simpler way was to make the space at the top of the cylinder smaller. The second method was to get a larger quantity of gas into the cylinder before the rising piston started compressing it.

For this a pump called a super-charger was constructed, which would force the mixture into the cylinder. The higher explosion pressure that resulted tended to drive the engine faster, and so further added to the horse-power.

You might quite naturally imagine that if you doubled the speed at which the engine worked the horse-power would be doubled, as shown in the diagram (fig. 1).

But the increase of horse-power was only that shown by the dotted line of the diagram. A maximum value is reached, and afterwards any additional speed actually produces less horse-power.

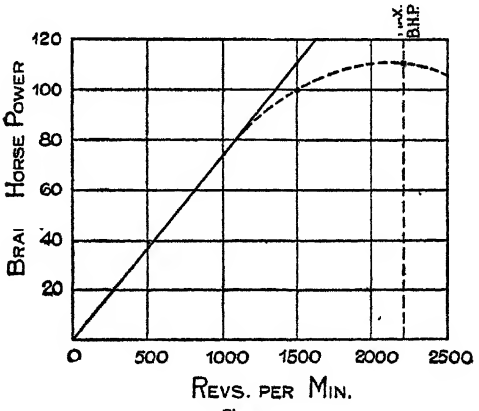


Fig. 1

Why should this be? you will ask.

It was due to the difficulty of getting a full charge of gas into the cylinder at high speeds, owing to the friction on the sides of the passages through which it must pass.

Again, the burnt-out gases gave trouble: they could not escape sufficiently fast through the exhaust ports. This caused a certain amount of

"back pressure" which used up some of the power the engine generated.

A third factor was the friction of moving parts of the engine itself, which absorbed much of the added power.

Lastly it was found that the higher speeds and higher pressures resulted in higher temperatures which threatened fresh trouble—the explosion of the gas in the cylinder before the piston was ready for it. That is, detonation. So the problem of detonation was tackled, and long research was carried out.

. . . . . .

Now, petrol is a mixture of three series of hydrocarbons called respectively aromatics, napthenes, and paraffins, in proportions varying with the locality of the wells.

Of the aromatics, benzol is one of the best known and the least likely to detonate. The paraffins are the most troublesome.

They found that by careful blending, so as to increase the proportion of the aromatics, detonation was much reduced, and it was possible to use the higher compression pressures we mentioned previously. No doubt you will now understand one of the reasons for the popularity of the various brands of "Benzol" mixture you see on sale at the garages.

In the last twelve years, as a result of this

work on fuels, there has been an all-round increase in power output and economy from 10% to 15%.

But the experimenter was not satisfied with the method of blending alone; he discovered that certain metals, such as lead and thallium, will greatly help to stop detonation even if there are only slight traces of them in the fuel. The difficulty was how to get the metal into the fuel. It could not possibly be ground fine enough to float about in suspension. Progress was held up again whilst this device was tried and that, until at last the solution of the problem was found in the use of a compound of lead which will dissolve in petrol. This compound is lead tetra-ethyl. Hence the "Ethyl" of the Anglo-American Oil Company.

By the use of such fuels, the compression-ratio may be raised to over four times its value in the early engines. This is one of the secrets of the success of the latest Rolls-Royce engine—high-compression ratio and a fuel specially prepared for the engine.

Intense Heat of an Engine. And now for that menace of heat.

Perhaps you have never realized what an intense heat is developed in the cylinder of a motor-car engine every time the gas is fired. In the heart of the flame the temperature is

about 2500° F. (Water boils at 212° F.) If steps were not taken to carry away large quantities of this heat, the moving parts would rapidly swell and "seize up", that is, become wedged together immovably. Furthermore, the heat is likely to destroy the nature of the lubricating oil, a film of which should prevent the moving parts being actually in contact with their neighbours.

Now you see the importance of an efficient cooling system. Most cars have their cylinders surrounded by water flowing through jackets, and then passing into a radiator placed well forward to allow the air to pass freely round it and carry the heat away, so that cooled water may return once more to the hot cylinders.

In the early days of aeroplanes a French designer decided to break away from all previous types of engine in order to attack this problem of cooling. You know how the cylinders of motor-cycle engines have fins cast on them so that air may flow over them and keep them cool. Such engines are said to be air-cooled.

M. Seguin, considering that the cooling effect of the fins depended on the rate at which the air moved over them, decided to make them move through the air. Instead of making the crankshaft rotate while the cylinders re-

mained fixed, he reversed the process, kept the crankshaft fixed and allowed the cylinders, seven or nine in number, arranged like spokes of a wheel, to spin round. Here was something really brilliantly new. So high was the rate of air flow over the cylinders that the engine was if anything overcooled.

This was the world-famous Gnome engine, which for a time swept all before it.

Why was not the well-tried water-cooled system of the motor-car employed successfully in the early days of flying? It is the same story —the struggle to keep the weight down. Water, piping, and radiator added weight which could not be borne when man was just beginning to get into the air.

As time went on, however, and power increased, it was found possible to adopt the extra reliability that was thought to go with the water-cooled system.

After nearly thirty years of flight the battle between "air-cooled" and "water-cooled" is still undecided. On the whole there is a slight tip of the balance in favour of the air-cooled type in England and America; while France, Germany, and Italy show a preference for the water-cooled engine.

As far as the Schneider machines are concerned, the adoption of the Rolls-Royce engine

has decided the question in favour of water-cooling. When we come to the plane we shall have something to say about the radiator.

To return to the troubles of the designers of aero-engines. They found another effect of the intense heat generated in the cylinders. The exhaust-valves, over which pass the flames of the burning gas, suffered most. They warped, or broke, or pitted (i.e. their seatings were pitted with little holes).

The metallurgist, the man who studies the character of metals, now joined in the fray. His researches it was that brought to the task new metals, metals which seem to be able to withstand the highest temperature that might be generated.

A Miraculous Engine

Now let us come to some of the actual details of this miraculous Rolls-Royce engine.

The work of producing an engine capable of beating our own Schneider Cup record of 1929 was not taken in hand until the end of January, 1931, when it was definitely announced that Britain would compete in the Schneider Contest in the following September. The time was now far too short to allow of a new engine being designed, so it was decided to see what could be done to increase the power output of the

type of engine that won the trophy in 1929.

On the face of it, this appeared an impossible job, for the engine, with a weight of only 1530 lb., and an output of 1900 h.p., seemed to have reached the limit of efficiency. Yet if the 1929 performance were to be bettered, the new model must give more power: it must be lighter, and its "frontal area" be less for a given horse-power than that of previous engines The "frontal area" will be dealt with when we come to consider the planes.

A good idea of the efficiency of an engine may be obtained from the number of horse-power given out by every hundred cubic inches of cylinder capacity. A normal aero-engine develops about 37·8 h.p. per 100 cubic inches.

The 1929 engine gave the astonishing figure of 90 h.p. Fitted in the Supermarine S.5 it had put up a world's speed record of 357·7 m.p.h. The task set the designers of the engine and plane was the beating of those wonderful figures.

It was decided to make three main changes. These were:

1. To increase the engine speed.
2. To raise the supercharger-gear ratio.
3. To enlarge the size of the air-intake.

You will note that Nos. 2 and 3 were to enable a larger quantity of gas to be taken into

each of the twelve cylinders, thereby raising the compression pressure for the purpose already explained.

In addition, the whole engine was carefully gone over with the aim of reducing weight wherever possible.

As was to be expected, many difficulties arose. The aim in view was to produce an engine that would successfully run an hour's test on the bench, at full power. By 20th April, the experimental engines would run only a few minutes before some failure would occur.

This time had risen to about half an hour by the middle of July, and on 3rd August a run of 58 minutes was made at the output of 2360 b.h.p. Success was reached on 12th August, just one month before the contest, with an hour's non-stop run at 2350 b.h.p.—a very wonderful achievement.

In this engine the velocity of the air through the intake on its way to the carburettors is 400 m.p.h. This, you will see, is about equal to the speed of the plane, so that a scoop, facing forward, is of great assistance in feeding air to the supercharger. It would take too long to recount all the troubles that were met with, the excessive oil consumption, the failure of the bearings, and the difficulties with valve springs. Suffice it to say that they were all

satisfactorily overcome in time for the great day.

Surely, when we realize what a marvellous feat this was, we cannot be too proud of the British engine-designers, aeroplane constructors, and pilots.

The full significance of their success is to be seen in the fact that both France and Italy, two of the world's chief air powers, could not complete their preparations for a contest that would have meant so much for their technical prestige.

The Plane

Do you know how and why an aeroplane lifts?

An aeroplane is simply a kite in which the engine and propeller take the place of the string. If you lean your weight on a table, the table pushes back as hard as you are leaning. If it did not, it would move and you would probably fall. Let us see what is happening around the wings of an aeroplane in flight.

Imagine that it is possible for you to view the end of the wing sweeping forward through the air, and that to make visible the movements of the air, suppose that smoke is mixed with it.

The section of the plane or wing is curved as shown (fig. 2).

An imaginary line joining the leading edge to the trailing edge is called the chord of the

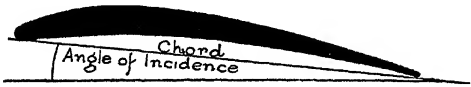


Fig. 2

plane. This makes a small angle with the line of flight (Angle of Incidence).

In the next drawing (fig. 3) lines are added to represent the flow of air above and below the wing.

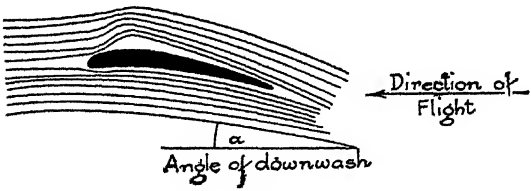


Fig: 3

I suppose that two things will at once strike you about this diagram. First, that a large body of air is being deflected downwards, and second, that there is a semi-vacuous region above the plane, just behind the leading edge. The wing, as it were, leans on the air and pushes it

down, while the air, like the table, pushes back and lifts the wing. The semi-vacuous region (fig. 3), being at a reduced pressure, acts on the upper surface of the wing by suction; indeed, in an aeroplane wing about three-

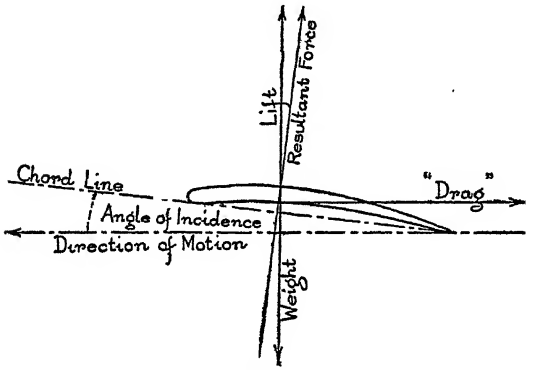


Fig. 4

quarters of the total lift is derived from the top surface.

The faster the plane moves, the greater would be the lift. The direction in which the resultant force acts is at right angles to the chord, as shown by the arrow (fig. 4). Since the chord is slightly inclined to the direction of flight, the force may be considered as built up from two components, one acting vertically (the

lift) and the other horizontally backwards (the resistance or drag).

The lift is essential, but the resistance is a hindrance. So you will notice that just as the engine-designer has been steadily driving down the weight horse-power ratio, the aeroplane designer and constructor has striven to reduce the proportion of resistance-lift. In other words, he tries to get as much lift from his planes as he can, with as little drag or resistance to forward motion as possible.

Unfortunately, the body, engines, landing-gear, and all other projecting parts produce a very considerable amount of drag, without taking any great share in the lift.

Here, then, you find another series of problems which have required all man's ingenuity and manual or technical skill for their solution.

The cause of the resistance is twofold. One part of the drag is due to regions of " dead air " set up by anything that causes a break in the steady flow. Although described as " regions of dead air ", they are places of turbulence and eddies, produced by a wasteful expenditure of power. The other part of the drag results from air which, although otherwise flowing freely, is actually rubbing along the surfaces of the various parts of the craft. This kind of resistance is called " skin friction ". It causes

a waste of power which does not, however, become serious until really high speeds are reached.

What are the obvious methods of reducing resistance?

First, a thorough research into the behaviour of curved wing surfaces at varying speeds and angles of incidence. You may wonder why *curved* surfaces rather than *flat*, which would be much simpler to build. It was early discovered that the lift-drag ratio for flat surfaces was very low. The shape of the wings of a bird gave the first workers the hint that perhaps here might be the means of solving one of their difficulties. The application of the cambered or curved wing gave an immediate improvement (see fig. 2).

One famous man who took part in the research mentioned above was A. G. Eiffel, the builder of the Paris Tower of that name. Using that building as his laboratory, he dropped flat plates and carefully observed their manner of falling.

Later the problem was investigated in a way that simulated the actual conditions of flight so well that great things might be expected and were achieved. A wind channel or tunnel, a large horizontal pipe, was erected through which, by means of powerful electric fans, a steady current of air was driven at a known

speed. An exact scale model of the wing or part to be tested was supported in the middle of the channel by an attachment to a very delicate balance.

When the fans are working this instrument allows of measurements being made of the forces acting on the models under very similar conditions to those experienced in flight.

Allowances have to be made for the reduced scale effect, and as a result of years of tests on wing sections of various shapes, new types have been evolved with greatly improved values of lift-drag.

Such new types have been of invaluable assistance to the designers of the recent high-performance gliders that have created so many new records in motorless flight.

The wind-channel has also been equally helpful in deciding suitable forms for the bodies of planes, the fairings of engines, the envelopes of airships, and even the details of exposed fittings and wires.

It has been found that in order to avoid the production of eddies and turbulence, fair or streamlined shapes should be adopted.

It might be thought that a body of this form would pierce its way through the air with least resistance when travelling point foremost. Strangely enough, less resistance is experienced

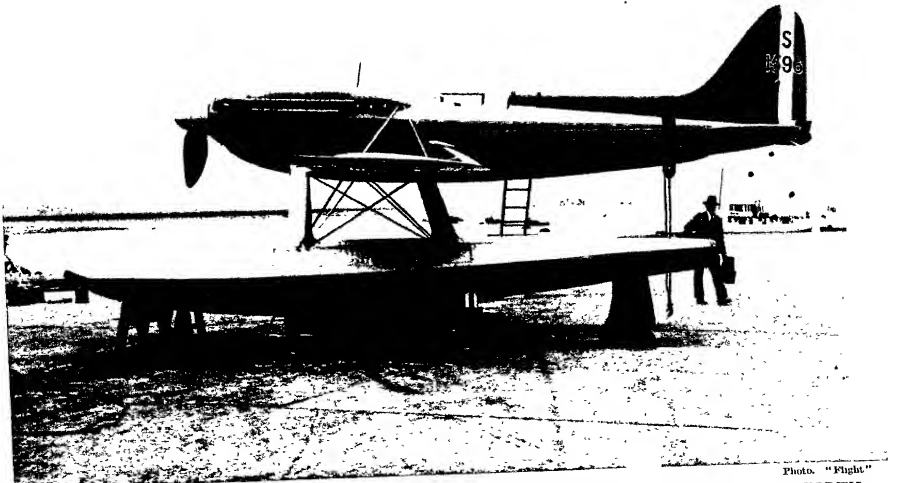


Photo. "Flight."

E 628

THE VICKERS SUPERMARINE S.6B MONOPLANE, IN WHICH FLIGHT-LIEUT. G. H. STAINFORTH MADE A WORLD'S RECORD SPEED FLIGHT

Facing p. 108

if it is flown blunt end first. The reason for this is that the air streams more freely round it and comes together with less disturbance after it has passed (figs. 5 and 6).

Also, if flown the latter way, the pressure of the air closing in over the rear part, instead of

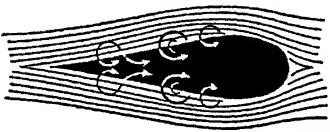


Fig. 5.—Showing disturbance when blunt end is at rear.

Direction of Flight

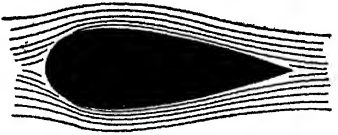


Fig. 6.—Showing smooth passage through the air with blunt end leading.

adding to the resistance, actually tends to help to move the body forward. Thus it is that all exposed parts have been gradually made to assume, as far as may be, a streamlined shape.

The second line of attack on the resistance problem is in the direction of reduction of the effects of skin-friction. You will have gathered from what has already been written that such friction may be reduced by careful attention to the nature of the surfaces exposed to the

air-stream. This, like our survey of the engine, brings us into the sphere of the metallurgist.

The early aeroplanes were structures of wood and fabric, braced with wire. Such craft had the merit that, if they crashed, and they frequently did, repairs and replacements were comparatively cheap and simple.

A serious disadvantage was that they easily became deformed, or lost their shape, and required trueing up. Furthermore, they suffered from changes of weather, and were most troublesome in tropical climates.

Metal would have been excellent had not the same difficulty faced the aeroplane constructors as had met the engine-builders—the need to keep the total weight of the structure within low limits.

So, like the engine, the aeroplane waited on the researches of the metallurgist.

Finally, a solution came in the production of stronger steels and light alloys, such as duralumin.

Given the newer materials, the plane designers had to commence their tasks all over again, not so much from the aerodynamic point of view, but rather with the calculations of stresses and strains in terms of the new medium.

The metal wing had arrived, suffering but

little from weather conditions, and capable of being finished with a smooth surface that would definitely lower the losses due to skin-friction.

You will by now have noticed how the results of researches in one direction are not limited to the purposes for which they are intended. They go on spreading out in all directions like ever widening ripples, helping to solve problems in other industries—surely an answer to those who cannot see the use of spending time and money on research unless it achieves a definite aim. The truth is that no one can foresee what will or will not be of ultimate use to mankind.

There is yet another method by which the total drag of an aircraft may be lessened, and that is by reducing its frontal area. Suppose you have a scale drawing of the front view of the machine made on squared paper. If you count the number of squares that the machine covers, you have a measure of its frontal area. The smaller the frontal area the less engine power will be needed to drive the craft at a given speed.

Human ingenuity has for long been exercised in reducing the value of this frontal area. The plane designer's part in the control has been largely governed by the frontal area of the engine supplied by the manufacturer.

While the engine-makers have been carrying on their struggle to get the weight horse-power ratio down, they have had at the same time to conduct a battle against excessive frontal area, and upon their efforts has depended the possibility of making a really high-speed aeroplane.

The outstanding example of success in this direction is seen in the Rolls-Royce R engine, which has, for a horse-power of 2300, a frontal area of only 6 square feet.

Following this short survey of the problems of the plane designer, from the angle of getting as much speed as possible from a given engine, some account must now be given of the clever devices that have been adopted to achieve these ends in the S.6B.

The Vickers Supermarine S.6B. low-wing monoplane is really quite a small machine. The wing span (distance from tip to tip) is only 30 feet, while the chord is 5 feet 8 inches. The wing area is only 145 square feet.

Thus it approaches the ideal set forth many years ago by an R.A.F. officer "to hang the smallest possible fringe of aeroplane round the highest powered engine"

The craft is waterborne by a pair of most carefully shaped metal floats which not only offer remarkably little resistance to the "take-off" but produce relatively little drag while

in the air. In early seaplanes difficulty was experienced in getting the machine "unstuck", even well after flying speed was attained. The floats seemed held by the water. Much work on the shape and construction of floats has made trouble much less marked.

The floats of the S.6B. are much more than mere supports—they are the main petrol tanks, and the upper surfaces are water-coolers adding to the radiator surface. The provision of an ordinary type of radiator would have produced far too much drag, consequently the actual surfaces of the metal wings have been ingeniously adapted to that purpose, assisted by the coolers on the floats.

The quantity of heat that must be regularly dissipated per minute to keep the engine at satisfactory working temperature is almost unbelievable. It amounts to 40,000 British Thermal Units, as much as would suffice to raise over twenty-six gallons of water from 60° F. to boiling-point.

Supremely efficient radiators these!

. . . . . .

There is another interesting feature to notice about these float tanks. Earlier in the chapter it was said that a push is resisted by another equal in intensity but opposite in direction. This fact is usually expressed by saying that action

and reaction are equal and opposite. Now, viewed from the pilot's seat, the propeller is rotating clockwise, and therefore there is a reaction which tends to rotate the whole craft in a counter-clockwise direction. This means that there is a force depressing the port float, and especially is this operative at the take-off.

To counteract this force depressing the port wing, one method is to make the starboard float carry more fuel than the port float.

So tremendous is the reaction in the S.6B. that at full power, when taking-off, it is equivalent to throwing an extra weight of 500 lb. on the port float.

Not only must water-cooling be employed to keep the cylinders at a workable temperature, but also the oil which is circulating round the engine must be cooled. This is done by passing it through cooling-pipes along the fuselage when it leaves the engine on its way to the top of the storage tank, which is placed inside the fin in front of the rudder. A difficulty arose in connexion with the system. It was found easy to take the heat from the cooling-pipes of the oil radiator, but not easy to transfer the heat from the oil to the surface of the cooler.

This was most cleverly solved by sweating small vanes into the oil-ways to ensure that all the oil came into contact with the tubes.

Possibly one of the most difficult jobs to carry out was the arrangement of the controls so that at the terrific speed of 400
should still have the
his control. The final adjustments were made by the use of small fins or flaps mounted along the trailing edges of the rudder and elevators.

These could be bent until the best position was found, and although they were but a few square inches in area, they proved to be quite satisfactory.

The propeller was of metal, as is customary on seaplanes. The design of an airscrew capable of absorbing 2300 h.p. was an extremely difficult task. To find one which would just suit the aeroplane added to the difficulty.

One was tried having a diameter of 8 feet 6 inches compared with the 9 feet 6 inches of the 1929 machine, and strange to say it proved quite unsuitable and caused the machine to swing violently to port during the "take-off". Finally, one was chosen having a diameter of 9 feet 1½ inches, which gave a good "take-off" and a satisfactory performance. Enough has now been said to give a fair idea of the enormously difficult task that lay before the engineers when they were suddenly called upon to produce a world's record breaker, and also to show how splendidly they responded.

And now there remains but the human element to consider in this speed contest.

The Man

" What I ha' seen since ocean steam began
Leaves me no doubt for the machine: but what about the man?
The man that counts, wi' all his runs one million miles o' sea. . ."

KIPLING.

The labours of all those responsible for the S.6B. is a story of heroic endeavour and indomitable perseverance in the face of difficulty heaped on difficulty.

Their work was now accomplished. An engine of miraculous power was evolved. There was needed to crown their achievement a different kind of heroism.

A man of iron nerve, superlatively skilled and resolute, and ready to face death, was to be chosen to direct and control this amazing projectile.

That man was Stainforth—Flight-Lieut. G. H. Stainforth.

And so true was he to the great hour that he has written his name large around the world.

He was chosen from what is undoubtedly the finest team of speed pilots in the world, the British High-speed Flight, consisting of Squadron-Leader A. H. Orlebar, A.F.C. (captain of the team); Flight-Lieut. G. H.

Stainforth; Flight-Lieut. J. N. Boothman; Flight-Lieut. F. W. Long; and F.O. L. S. Smith.

It was Flight-Lieut. J. N. Boothman who, but a few days before, had won the Schneider Trophy Contest for Great Britain with a speed of 340·1 m.p.h. And it was Squadron-Leader A. H. Orlebar who had set up the record of 357·7 m.p.h. that was now to be attacked.

Every one of these had proved his quality in a hundred different adventures of skill and courage. These men, and these alone in all the world, knew the sensation of moving at six or seven miles a minute.

When Flight-Lieut. Stainforth, after his great flight, was humorously toasted, at a luncheon given in his honour by the Weymouth Rotary Club, as " the *fastest* young man in the world ", he replied: " I was just one of a team. Anyone else in the team could have done it, and probably a hundred others in the Air Force would have. The machine never let me down."

Maybe that is as true as it is generous. But the fact remains that Stainforth was the man selected.. " The machine never let us down," he said. What if it had? What would be the consequences? What were the risks?

Well, wings have been torn off planes travelling at only 100 m.p.h.; controls have jammed;

rudders have been swept away; ailerons have refused to act; petrol-leads have broken and roaring flames enveloped the machine.

Many pilots overtaken by such accidents have saved their lives by parachute, but there would be no escape at six miles a minute. There would be no time to get out. Any of those, and as many more possible defects, would mean sudden death.

The air-pressure is so tremendous that did the airman but move his head outside the screen, his neck would probably be broken, and certainly he would be suffocated.

And this is when the machine is travelling in a straight line. If a curve or turn is taken, another force at once comes into play—centrifugal force—by which the pilot's body tends to fly outward. This causes his body to become three or four times heavier, so that he is unable to as much as lift an arm.

Not only has every part of the craft to bear the strain of this enormous pressure, but also possibly the shock of striking water.

Now water is an almost incompressible fluid, and when hit at speed behaves very much like a solid. Many a wooden propeller in the early days of seaplanes was smashed to bits by just catching a few drops of water either thrown up by the floats or blown from the wave-tops.

The introduction of the metal-tipped propeller blade lessened this danger, whilst the adoption of the all-metal propeller has almost removed it. But even then, at the take-off, and again at the landing, if even a slight swell is hit, the craft will "porpoise" and the pilot is pitched about violently in his seat, whilst the floats smack upon the water with loud cracks. On landing after his very last flight, Stainforth's racing plane had hit the water and capsized.

For these terrific speed-tests, the take-off and landing must be at speeds of over 100 miles an hour. That is why the machine used is a seaplane, for with a landplane an immense aerodrome would be required, and the danger of such a high-speed take-off and landing would be too great.

These, then, were a few of the difficulties and dangers that were in the mind of Stainforth when at 5.50 p.m. on 29th September, 1931, he climbed into the small cockpit of S.6B. and was securely strapped to the seat.

The roar of the engine grew louder and louder, the whirring of the propeller blades set up a mighty wind that ruffled the surface into a myriad ripples. There was the sense of an immense energy, an intense force, quivering through the machine and straining to be released.

There was a delicacy, a lightness of touch in all the controls. Such a sense of response to the lightest touch is known to all who have driven a fast car tuned up to the second, or sat a blood horse, quivering at the starting-post with impatience to get away.

This extreme delicacy is spoken of as "feel" —"nice feel"—and must be matched with like delicacy of touch on your part. The slightest harshness or heaviness at your hands, and the sensitive thing whose spirit is leaping with yours is grievously hurt.

Firmly yet lightly the pilot held the joy-stick, his nerves steady, his eyes clear, his mouth firm.

Almost as soon as the plane slid off the pontoon (a kind of raft for transporting the craft from the station to the starting-point) he opened out his engine.

The plane left the water at an angle (which is always greater than can be maintained) and shot up and forward.

Here was the first test of training and skill: to move the control-lever so gently forward that the craft is set to the desired angle of climb.

The method of flying the Schneider course differed from that required in attacking the speed record. The former contest was flown round a closed course, triangular in shape and

containing two exceedingly sharp turns. The successful negotiation of these turns called for careful scientific calculation and practice in their execution.

Errors here would have meant an increase of the distance to be flown and the loss of precious seconds.

The speed test, on the other hand, was flown over a straight course three times in each direction. The flights to and fro were to ensure that on the average no assistance was received from the wind. At first it might be thought that what is lost by flying against the wind is made up when flying with it. However, this is not so, as the following example will show.

Suppose a machine having a speed of 150 m.p.h. is flown in a calm from A to B (a distance of 100 miles) and back again. It will take 40 minutes for each trip. The total time for the 200 miles at 150 m.p.h. is 80 minutes.

Now let a 50 m.p.h. wind blow from A to B. Going from A to B, the wind adds 50 m.p.h. to the speed of the plane, making a ground speed of 200 m.p.h. The time from A to B is now 30 minutes. On the return trip the wind subtracts 50 m.p.h. from the machine's ground speed, which is now only 100 m.p.h. The time for the return is 1 hour. The total time is 1½ hours, or 90 minutes. So it is seen that the

wind has reduced the average speed from 150 m.p.h. to 133½ m.p.h., and the assistance from the wind does not make up for what is lost when flying against it.

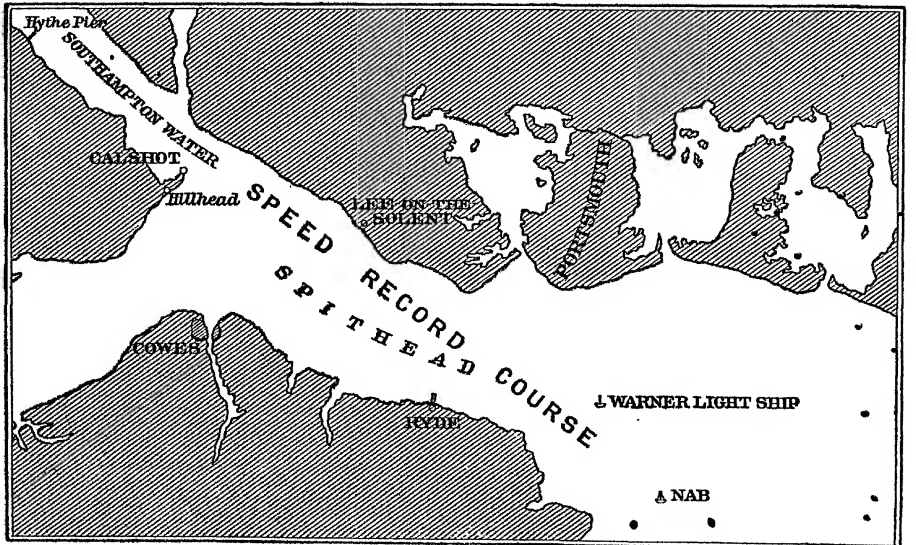
Stainforth rapidly gained height, ran the engine in, and in order to satisfy himself that all was well before attacking the record, made a wide sweep almost out of sight. Then he came full out on level flight, parallel to, but above the course.

All was well. Now for the great effort.

With terrific roaring of the engine he shot away over the Solent. The roar sank to a purr, the rapidly diminishing shape became a faint dull streak and almost disappeared in the soft greyness. The purring came again, increased to a shriek, and he was rushing back in a dive towards the Lee-on-Solent end of the course. At Calshot he climbed as he took the turn to prepare for the second lap, and then dived towards the Hillhead point.

Those dives!

He must have been shooting down at 500 m.p.h., and he had to flatten out at a height of only 150 feet above the sea. What a delicacy of touch was needed here, what perfect sight and judgment! A fraction of a second too long down that swift path and he would hit the sea and come to instant death.


Hythe Pier
SOUTHAMPTON WATER
CALSHOT
Hillhead
SPEED RECORD COURSE
SPITHEAD
LEE-ON-THE-SOLENT
PORTSMOUTH
COWES
RYDE
WARNER LIGHT SHIP
NAB

If at a turn he put the joy-stick over and pressed the rudder-bar less than half an inch, he would be driven instantly from the horizontal to the vertical (as indeed he was) in a great sweep of 600 or 700 yards.

Moreover, in that vertical position, suddenly blindness comes. The pilot's head is sideways, there is an enormous pressure of air acting upon it, and the blood is driven from the brain. This blinding is known as "blacking out". Hesitation would be fatal, for although the high-speed pilot knows from experience that he can remain "blacked out" and yet be conscious, he would, of course, be flying blind.

Instantly, therefore, he moves the joy-stick back to regain the normal and his sight returns.

Five laps Stainforth did, and the best consecutive four of these made the record.

Many wonder how the times are taken, and indeed it is no easy matter. Cinema cameras are used, which, besides recording the passage of the aircraft over certain points, register the time at which it passed.

After the fifth lap Stainforth came sweeping over Southampton Water towards Calshot, flying low and wheeling as he came. He was searching the water for a good "landing", for which there must be at least three miles of clear water ahead, and the manœuvre is, at the

best of times, most difficult and dangerous.

The engine was throttled down, the plane came down in a long graceful dive, so that the water was approached gradually.

Gradually her speed diminished, and then, when close to the water, she was flattened out.

If the pilot misjudged the angle and came down too acutely, disaster would follow.

The danger of landing is largely due to the difficulty of estimating height above the water, as there are no distinctive objects to give distance.

That too is one of the difficulties during the actual flight, for the forward angle of vision is not much more than 45°, and the steering is largely carried out by bearings on cloud banks.

During the whole flight of 28 minutes, Squadron-Leader Orlebar was up in another machine giving guidance to Stainforth in judging the height at which to make his dives.

And so the record speed flight of the world was broken, and Flight-Lieut. Stainforth came in, looking perhaps a little weary about the eyes, but as if he had enjoyed the great adventure.

And here is the hero's own log report: "The visibility was not perfect—opened throttle quickly and got nearly full revs., with little misfiring.

" Slight porpoising in take-off was damped out after throttling down slightly.

" Machine accelerated rather slowly and was tail-heavy, but engine soon got going, and at 200 m.p.h. on the air-speed indicator tail-heaviness disappeared.

" Made my turns from Warner Lightship at one end and the Hythe Pier at the other. Was flying by cloud formations. The engine was good throughout."

Light cloud formations, being almost stationary, were used as sighting marks. The fastest lap was 415·2 m.p.h., but during the dives the speed was not less than 500 m.p.h., and the official figure returned for the record was 407·7 m.p.h.

By the King's order the two pilots, who had so well represented their team, were awarded the Air Force Cross:

" Flight-Lieut. J. N. Boothman in recognition of his achievement in winning the Schneider Trophy Contest, 1931; and Flight-Lieut. G. H. Stainforth in recognition of his flights with the High-speed Flight of the Royal Air Force in connexion with the Schneider Trophy Contest, 1931, culminating in the establishment of a world's speed record on 29th September."

The exploits of these two brilliant airmen

set us wondering to what they owe their success. Do we not wish to know what manner of boys they were? Did anybody say of them, "One day those two will be famous"? Were they always in some fine adventure, or did their books or their own fair dreams hold them?

Well, part of their schooldays was passed in the most troublous and stirring times, for the Great War was raging. Whilst still a boy, at the age of sixteen, Boothman decided to take part in it, and leaving the Harrow High School he volunteered for service in the French Red Cross. He soon gained distinction, and for his devotion to duty in the Balkans between January and September was awarded the Croix de Guerre.

It was natural that his love of adventure should lead him to the Air Force, and in 1921 he was granted a short-service commission in the R.A.F. with No. 4 Squadron, at home and at Constantinople. His exceptional qualities were quickly recognized, so that he was appointed an A flying-instructor at the Central Flying School. Two years later, a permanent commission was granted him, and in the autumn of 1926 he saw service with No. 55 Bomber Squadron in Iraq.

After being on the Iraq Air Staff, and holding

several other appointments, he came to England to join the Marine Aircraft Experimental establishment at Felixstowe for research work on high-speed aircraft. In May of 1931 he joined the High-speed Flight and entered upon the hard training for the fine endeavour that brought honour to himself and his country.

Flight-Lieut. G. H. Stainforth is two years older than Flight-Lieut. J. N. Boothman, and was educated at Dulwich, Weymouth College, and Sandhurst. A few weeks after his record flight, he revisited his old school at Weymouth, and so enthusiastic was his welcome that he said it was the greatest ordeal of his life.

At nineteen he received a commission in the Buffs and served in France, India, Iraq, and Aden. In 1922 he returned from the regular army, and was given a short service commission in the R.A.F. He was posted as a pilot to No. 19 Fighter Squadron, and later became an instructor in No. 4 Flying Training School in Egypt. When the High-speed Flight was formed in 1928 for training for the Schneider Trophy, he was posted to it, but to his great disappointment he did not fly in the 1929 Contest, because his Gloster Napier 6 was not ready.

But 10th September, 1929, was a great and happy day, for then he wrested the world's

speed record from the Italians with a speed of 336·3 m.p.h.

With his keen sight and steady hand it is not surprising that he was in the R.A.F. rifle and revolver teams from 1923 to 1930, was R.A.F. rifle champion, and in the King's "100" at Bisley in 1928, and later was revolver champion.

He is a man of iron nerve. His record flight was made a few days only after the accident already referred to, in which his machine sank and he narrowly escaped drowning.

He is, besides a hundred other things, boy-like and unassuming, and one who loves adventure for adventure's sake.

When, after some hours occupied in developing the films of the great flight, the news of his achievement was brought, he was found in the officers' mess at Calshot enjoying a game of shove ha'penny.

"I thought I had done it," he said, and then went on with his game.

To what purpose, it may well be asked, is all this heroism? No better answer can be given than that contained in the next chapter, which shows how now, as a result of all that has gone before, we may travel upon an air-route in perfect comfort, and in wellnigh perfect security.

PART V

Taking G-XM to Paris

Finding your way in the Air

Have you ever spent a holiday on the south coast of Kent? If so, no doubt you have watched the various aircraft leaving our shores for the Continent. The great biplanes of Imperial Airways bound for Le Bourget (Paris) crossing the coast near Dungeness, the low-wing, all-metal Junkers monoplanes of the German Luft Hansa passing out seawards above Folkestone, taking the same route as the dark-blue high-wing Fokkers of the Royal Dutch Line, the K.L.M. going to Amsterdam—all these and others must have attracted your attention.

I expect you have wished yourself in charge of one of these craft, and wondered how you would find your way through all the miles of cloud, blue sky, mist or rain to your terminal aerodrome. Let us suppose your wish is realized, and you are seated in the pilot's cockpit facing a bewildering collection of instruments and gadgets. First and foremost

you would recognize the " mariner's " compass, transformed to suit the new conditions of a rapidly moving aircraft. This is one of the most important means to help you to reach your destination, since it enables you to know in which direction your plane is pointing. Unfortunately this is not necessarily the direction in which the machine is travelling. There will almost surely be a wind blowing and either helping or hindering the aeroplane's progress and causing a certain amount of " drift ".

It is most important that you should know the direction and the amount of this drift, for a reason that will be made clear shortly.

The direction of the drift can be determined from the way in which the ground appears to stream away beneath you—not directly astern, as it would do if there were no wind. The amount of drift is the result of combined effects of the speeds and directions of the wind and of the plane.

As far as the wind is concerned, you may be able to receive these factors by a radio weather-report. Your " air-speed ", *not* your ground-speed, you can read from one of your many instruments—the air-speed indicator.

This drift, which is determined by the help of a drift-meter, must be allowed for in steering your craft, or you will soon be off your course.

A diagram will make this plain. Suppose you wish to fly from a town A to another B which lies 80 miles away to the north, and that you are flying at 80 miles an hour in a calm. You

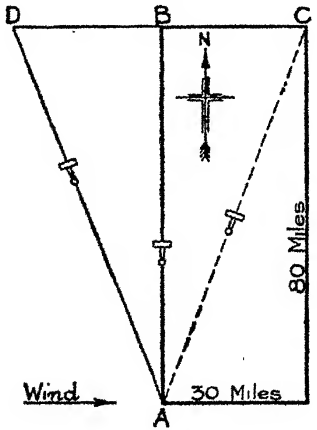


Fig. 7

will then fly on a northerly compass course, and will arrive at B after an hour's flight (fig. 7).

Let us now suppose that there is a steady westerly wind of 30 m.p.h. and that you start from A and still fly on a northerly course. While your engine has carried you 80 miles north of A, the wind will have swept you 30

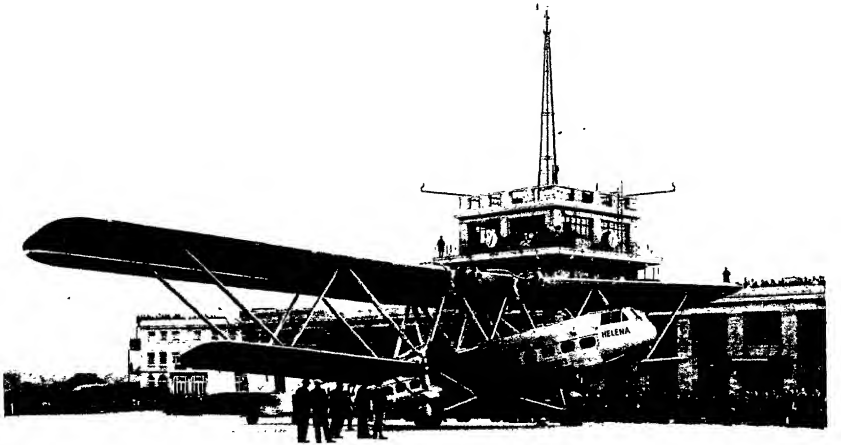


Photo. "Flight"

CROYDON: THE CONTROL TOWER AND AN IMPERIAL AIRWAYS LINER

Facing p. 192

miles to the east, and although you have kept the nose of your machine pointing north you will find yourself at C instead of B. Your real track is shown by the dotted line AC, while the line BC represents the amount of easterly drift in one hour.

Clearly if you wish to reach B under these conditions you must steer your plane in the direction AD, and then the combined effect of the wind and your engine will bring you to your destination.

Signposts of the Air

But it is not enough to know which way your craft is pointing, or even the direction in which it is going. You must know your position —where you are in this wilderness of space. That this can be done, even though you may be 10,000 feet up, in clouds so dense that the visibility is less than 50 yards, and while moving at 100 m.p.h., is a modern miracle which we owe to the wonders of radio transmission and reception.

Let us try to picture how this operation is performed. Imagine yourself standing somewhere out in a large hall which is quite dark (fig. 8), so that you cannot see where you are, and you wish to know your position (X).

You will need the help of two friends Y and Z at adjacent corners of the hall

Ask Y where he thinks you are. He will ask you to make some fairly regular noise to assist him to estimate your whereabouts. If he slowly turns his head round, he will find one particular position in which he can hear you best, and he will then feel instinctively that he is facing you. He knows that you are somewhere on the line of direction YX towards which his face is turned. But how far from

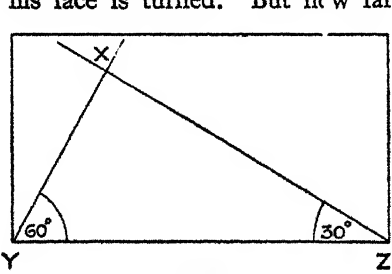


Fig. 8

him? He can only guess from the intensity of the sound you are making.

Now get Z to take a hand. In the same way he will decide you are on the line ZX, but he will not know where.

If Y and Z now compare their experiences, Y will say that you are on a line making an angle of 60° with the line joining him to Z, while Z says you are on a line making an angle of 30° with ZY. The only point which is on both

these lines is the point where they cross (X), and that is your position. If the distance from Y to Z is known, then the position of X can be easily found.

Thus you see that by using sound waves it has been possible to fix the position of an unseen person. Of course it is only practicable to use this method for aircraft when the distances are quite small. It was made use of during the air raids on London in the Great War. Any wind will distort the effect and give a false result.

With wireless waves we have a much more effective method. These waves are in the ether and not air-waves, and are therefore unaffected by winds, fog, or clouds; furthermore, their range extends hundreds of miles.

If you replace X by your plane's radio transmitter, and Y and Z by the operators of the Direction Finding (D.F.) apparatus at two aerodromes, you will find the process simplified.

Asking the Way

Here you are, 10,000 feet up in the clouds. You call Croydon Aerodrome on your wireless telephone transmitter, using a wave-length of 900 meters.

"Hullo, Croydon! Imperial Airways G-XM

calling. Will you please give me my position? Over."

The word "over" means that you have switched over from your transmitter to the receiver and are waiting for a reply.

In a second or two you hear your phones. "Hullo, Imperial Airways G-XM, Croydon, answering. Understand you require your position. Is that correct? Over." You agree. Croydon now asks you to run your radio generator. This is to provide the necessary signal for the aerodrome operator to listen to.

As long as the generator is energizing the aerial, a series of continuous waves are being radiated capable of producing a sound in the receiver telephones. Croydon calls up the operator at Lympne (near Folkestone) and at Pulham (in Norfolk), and all three stations listen for your waves.

Just as your two friends Y and Z turned their heads to find the position in which they could hear you most clearly in the darkened hall, so do the operators, by turning a knob carrying a pointer over a graduated dial, move round a "search-coil" or radiogoniometer to discover the direction from which come the waves emitted by your aerial system. Actually they note the dial reading when the sound is weakest, since it is easier to determine the

exact position by the weakest sound than the loudest; but the pointer is so fixed as to allow for this.

The reading thus obtained is the number of degrees in the angle enclosed between a north-south line and the line from the aerodrome to your position. Such an angle is called your "bearing"

You are answered

To see the completion of the operation, the whole of which takes less than two minutes, you must magically transport yourself to the interior of the Control Tower at Croydon Aerodrome.

An operator with telephones on his ears has just taken your bearing. Before him is a large scale map of south-east England and northern France. It is a most unusual kind of map, forming the top of a sloping desk. The position of Croydon, Lympne, and Pulham are marked by small holes through which pass coloured cords ending in small mouse-like weights serving as handles to stretch the cords in any direction across the surface of the map.

The lower ends of the cords below the surface of the map are weighted, so that whether they are pulled or released they remain stretched in a straight line.

Circles are drawn on the map round each of

the three aerodromes, and the circumference of each is marked in degrees, beginning at the north (0°) and going round in a clockwise direction to facilitate the setting out of bearings.

Now watch the operator plotting your position from the bearing he has found and the two supplied him by his colleagues at Lympne and Pulham. He takes the cord coming from the hole marked Croydon, stretches it, swings it round until it lies on the 136° mark on the Croydon circle. Then in turn he moves the other cords into their correct positions—Lympne 167°, Pulham 177°.

The three cords cross one another at a point on the map in the English Channel. That is your position which the operator immediately reports to you.

Probably you wonder why three bearings are taken when in your example in the darkened hall only two were used. The reason is twofold.

First, the plane might be exactly on the line joining the two aerodromes, in which case the bearing lines would never cross one another and the operator would not be able to get the point of intersection determining position.

The second advantage of the third bearing is the additional accuracy to be obtained from three lines. In practice they rarely cross at a point, but enclose a small triangle (the triangle

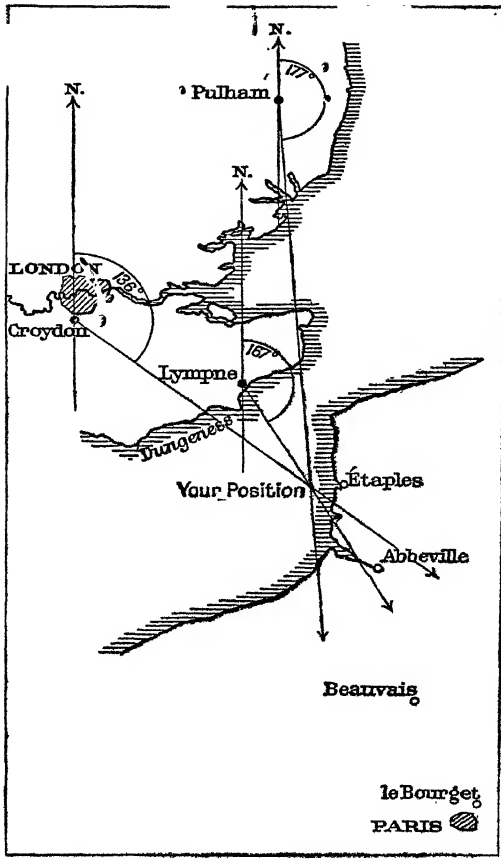


Fig. 9.—How a Pilot finds his position on the London-Paris Air Route

of error) at the centre of which your position is assumed to be

Since you took control of G-XM over Dungeness, your three Bristol Jupiter engines with their steady roar have driven you onwards till now, as Croydon reports, you are well across the Channel about fifteen miles west of Étaples. Happily the clouds are breaking up and the sun gleams through, while far below, through gaps in the cloud floor, a few fishing-boats are seen. Ahead lies the foam-flecked coast of France. Every minute the visibility improves. Once over the coast and you change your course by turning more to the southward. In the blue distance you catch sight of the towers of Abbeville. Still onwards you press, and with Abbeville behind, you are fairly on the highway to Paris, with the misty pile of Beauvais Cathedral as your next landmark and signpost.

Should the weather thicken again, the French D.F. Stations are at hand to help you when you call for position, course, or weather report.

So will you bring your craft in safety to the busy terminal aerodrome on the northern outskirts of Paris

PART VI

The Exploration of the Upper Air

"Higher still and higher,
From the earth thou springest
Like a cloud of fire;
The blue deep thou wingest. .

SHELLEY.

The Dreamer

A boy was lying on his back, alone, out on the crest of the sun-drenched downland. His arms were outstretched, one knee was bent, and there was a far-away look, a great wonderment, in his wide-open eyes.

His body truly was stretched there, on the turf, but he himself was on a great adventure, perilous, inspiring, romantic.

A skylark overhead poured down its stream of song, but he did not hear it; a rabbit, chased by a stoat, scuttled past, but he did not see it.

He was moving upwards through the sparkling air, up and up towards the sun; the earth on which his body lay was 10,000 feet beneath him: a white wall encircled him: the earth,

the sun, everything was hidden. He shuddered. The wall became thinner—he broke through it into a brilliant light. There was a deep blueness all around him, an intense stillness, a never-ending space . . . never ending, never ending. Up and up through this blueness, up to the very stars, and beyond them and still up and on for ever and ever, reaching no end, no boundary. Eternity.

The adventurer, stretched on the down, clenched his fists, rose slowly to his feet, and went away through the gorse, deep in thought.

Dreams come True

Some fifteen years later, upon a downland, a little crowd of helpers was holding down, with ropes, a balloon whose great envelope gleamed in the sunlight.

A man, his mouth resolute, and with those wide-open, unblinking eyes, stepped into the frail basket. The word was given, the ropes were loosed, and up shot the balloon.

The gleaming ball dwindled and dwindled, and then passed out of sight in the glowing whiteness of the unknown. Frail man in a frail craft, braving thus for Truth the terrors of limitless space.

Valiant, unconquerable spirit!

But a great mistake had been made, as great

mistakes must almost always be made by pioneers.

The envelope of the balloon had been fully filled, and as it rose higher and higher into the thinner air, which exerted less and less pressure, the envelope swelled and tightened, and at a great height burst.

Down rushed the adventurer, all hope deserting him. Then miraculously, the fabric of the shattered envelope, dragging on its supporting cords, filled out in the stream of air and, acting as a parachute, brought him safely to earth some miles from his starting-place.

Nothing daunted, Jeffries, for it was he, the dreaming boy upon the downland, with another equally courageous spirit, Blanchard, prepared for another ascent, and this time care was taken to inflate the envelope only partially. They reached 22,000 feet, and brought back much valuable knowledge concerning temperature and the quality of the air at great altitudes.

The Pioneers

This desire to penetrate into the secret places of the heavens has haunted the mind of man for centuries.

In 1749 Dr. Alec Wilson conceived the idea of measuring the temperature of the upper air by means of kites bearing thermometers, and at Glasgow he carried out a great many experi-

ments, carefully tabulating his results. Others followed with similar experiments that gave most valuable knowledge regarding winds and air-currents, the humidity of the air at various heights, and most important, the condition of the air around and about clouds.

Such information gave great assistance to those who, not content with kite experiments, made balloon ascents.

Jeffries and Blanchard made several successful ascents in 1784; and in 1803–4 great efforts to reach new heights were made by Robert, Biot, and Gay-Lussac.

On 16th September Gay-Lussac made a lone ascent from the Conservatoire des Arts, Paris, bent on discovering what happened to the force of gravity at great heights above the earth. If the pull of the earth produced an acceleration of 32 feet per second per second in a freely falling body at the surface, it surely would be less at, say, 10,000 feet, and still less at 20,000 feet.

So as he passed up he tested at every 1000 feet the force of gravity and found that there was no appreciable change, not even when he reached the great height of 23,000 feet.[1]

[1] In 1932, with a new type of gravitational altimeter, it was found possible to verify the expected change that Gay-Lussac's insensitive method could not record.

Between 9.40 a.m. and 3.45 p.m he made tests at ever-increasing heights of the magnetic force, and found that again there was no variation.

At 23,000 feet he filled a vessel with air, and on returning safely to earth, tested it with a similar vessel of air taken at the ground. Except for the lower density there was no difference The air at 23,000 feet had the same qualities as air at the earth's surface. But temperature? His thermometer at starting registered 87° F., and at 23,000 feet it was down to 14·9° F. Greatly to his surprise, there were clouds still moving above him.

Knowledge of the upper air came very slowly, as may well be imagined, considering the expense of each adventure and the enormous danger.

John Welsh added his mite when in 1852 he left the then famous aeronautic ground at Vauxhall and attained Gay-Lussac's height of 23,000 feet. He had set out to investigate temperature and the humidity of the air at various altitudes, and came back safely with facts which, placed alongside those of previous explorers, half revealed a new truth to the world.

Ten years later the British Association, then as now a body of the most eminent scientists of the day, commissioned Coxwell, a professional balloonist, to make a series of ascents, provided

him with a balloon, and paid him £25 for each ascent.

A Great Adventurer

An observer was needed. James Glaisher, a member of the Committee of the British Association, offered his services, which being accepted proved of the greatest value to the science of Aerostatics.

Glaisher's efforts were concentrated on the following tasks:

To compare the readings of a mercury barometer and the aneroid, in order to find the relative value of the instruments for registering altitudes.

To find the temperature at which dew-point occurred.

To find the temperature of the air at various heights, and the pressure of the atmosphere at those heights.

To find the electrical condition of the air at various heights.

To find the composition of the air, and the proportion of oxygen as the temperature fell.

To make sound observations.

To examine the rate and direction of air currents, under and above, and in clouds.

To examine the heat, the density, and the thickness of certain types of clouds.

To test samples of air brought down from various heights.

This was a most important adventure which, it was hoped, would gather up all the uneven threads of knowledge into one orderly pattern of definite form.

The eyes of the scientific world were therefore turned upon Glaisher and Coxwell in the year 1862.

So far, you will remember, 23,000 feet had been the greatest height attained. But now on 5th September our two adventurers shot up from Wolverhampton and sped rapidly towards the clouds, intent on a far greater altitude.

Up they climbed, making observations as they travelled. They reached the 23,000 feet attained by Gay-Lussac, and passed beyond.

Now they were in regions where no man had ever been, and still they climbed.

They reached 29,000 feet, and what happened then let Glaisher tell in his own words:

"I laid my arm upon the table, possessed of its full vigour, and, on being desirous of using it, I found it powerless; it must have lost its power momentarily. I tried to move the other arm, and found it powerless too. I then tried to shake myself, and succeeded in shaking my body. I seemed to have no limbs. I then looked at the barometer; and whilst doing so my head

fell on my right shoulder. I struggled and shook my body again, but could not move my arms. I got my head upright, but for an instant only, when it fell on my right shoulder, and then I fell backwards, my back resting against the side of the car, and my head on its edge; in this position my eyes were directed towards Mr. Coxwell in the ring.

"When I shook my body I seemed to have full power over the muscles of my back, and considerable power over those of the neck, but none over either my arms or my legs; in fact, I seemed to have none. As in the case of the arms, all muscular power was lost in an instant from my back and neck. I dimly saw Mr. Coxwell in the ring, and endeavoured to speak but could not; when in an instant intense darkness came, the optic nerve finally lost power suddenly. I was still conscious, with as active a brain as at the present moment while writing this. I thought I had been seized with asphyxia, and that I should experience no more, as death would come unless we speedily descended.

"Other thoughts were actively entering my mind, when I suddenly became unconscious as in going to sleep.

"I cannot tell anything of the sense of hearing; the perfect stillness and silence of the

regions six miles from the earth (and at this time we were between six and seven miles high) is such that no sound reaches the ear.

"My last observation was made at a height of 29,000 feet; at this time (one hour, fifty-four minutes) we were ascending at the rate of 1000 feet per minute; and when I resumed observations we were descending at the rate of 2000 feet per minute. These two positions must be connected, taking into account the interval of time between, viz. thirteen minutes, and on those considerations the balloon must have attained the altitude of 36,000 feet or 37,000 feet. Again a very delicate minimum thermometer read 12 degrees, and this would give a height of 37,000 feet. Mr. Coxwell, on coming from the ring, noticed that the centre of the aneroid barometer, its blue hand, and a rope attached to the car, were all in the same straight line, and this gave a reading of seven inches, and leads to the same result. Therefore these independent means all lead to about the same elevation, viz. fully seven miles."

When Glaisher was lying unconscious, Coxwell was resisting with all his power the somnolence that was creeping over him. In a few moments the stealthy, moving hand would be laid upon the brain.

He tried to shake himself free and pull the

valve-cord to release gas and send him down. But his hands refused to obey his will. They were surely lost now. With a last effort he reached the cord with his mouth, got it between his teeth, and, with perhaps the very dregs of his energy, pulled.

The valve opened, and as they came down, the torpor passed from Coxwell, who had then the inexpressible relief of seeing Glaisher stir and gradually regain full consciousness.

Glaisher found that his pulse, which at the start was 76, rose to 90 at 10,000 feet, to 100 at 20,000 feet, and finally reached 110.

It is found, however, that pulse and facial hue are dependent on individual temperament, so that at 10,000 feet, whilst the faces of some would take on a glowing purple, others would show scarcely any variation from the normal.

At four miles high, Glaisher could distinctly hear the pulsations of his heart, and at the slightest exertion his breathing became short, sharp gasps.

From his observations on this and other flights, he came to the conclusion that sound at great altitudes depended largely upon the amount of moisture present in the air. Thus sounds came up to him from earth when he was in cloudland, at 10,000 feet. He heard the report of a gun, a little higher the barking of a

dog, and then the sound of a train moving four miles beneath him. But when clouds stretched between him and the earth, there was no sound whatever, and at their greatest altitudes the silence was again profound.

Very few have emulated the exploit of Glaisher and Coxwell.

Tragedy

In 1875 three aeronauts, H. T. Sivel, T. E. Crocé-Spinelli, and Gaston Tissandier, took their place in the car of the balloon *Zenith*, and set off to reveal fully, if they could, the half-realized truths that had come to earlier adventurers.

Up they sped, the air getting colder and colder and thinner and thinner. At 10,000 feet, they had put on all extra clothing; at 15,000 feet, Sivel's hands were numbed and his face frost-bitten; at 20,000 feet, all three were breathing at almost twice the normal rate in order to get sufficient oxygen from the rarefied air in which they were moving, and their hearts were thumping proportionately fast.

But there was no thought of abandonment, no thought of defeat. On and on they went to 21,000 feet, 22,000 feet, 25,000 feet. And now, Sivel, his heart pounding, his respiration reduced to short gasps, saw only blackness

before him. His eyes closed, his head fell forward, and he dropped in a swoon to the floor of the car.

Tissandier and Crocé-Spinelli hauled him up, lent his head gently against the basket-side, and, suffering as they also were, spoke words of encouragement.

A few minutes later, Spinelli was overcome by the intense cold, and collapsed. Gaston Tissandier was now alone in the blue inverted bowl of the sky. There was absolute silence—silence such as is never known on earth—a silence against which the waft of falling leaf would be noise. It was the silence of the awful immensity of space.

Tissandier felt no upward movement, no wind, nothing.

He was just suspended in a deep, deep, blueness—floating as if in a dream.

But this cold, this gasping—and still he was rising.

How much longer before he too fell suddenly insensible?

He glanced at his barometer. No, the balloon had not yet reached its ceiling. On then to the end!

At 27,000 feet no further height was registered. That, then, was the end of the adventure, and it was as well, for Tissandier could scarcely

raise his arm to pull the valve-cord and release the gas.

As he descended, his breathing grew less laboured, his heart-beat less fiercely, a little warmth crept back to his frozen limbs. He looked at his companions, but no warmth had come into their cheeks; no warmth would ever come again into their cheeks. They were dead.

But the veil of the unknown had been drawn back yet a little farther.

Secret Places of the Heavens

Other explorers were pushing out in various directions. There was a little band engaged in investigating the mystery of clouds, how and when they formed, their heights, their temperature, their effect upon the surrounding air. Maybe in the country of clouds there were regions of intense cold, of soft warmth, of strange magnetic and electric influences. Through the vast valleys of cloudland, what fierce winds were sweeping, what new forces were at play?

One, Luke Howard, patiently observed, and eventually made a valuable classification of cloud forms.

M. Hermitte and others followed him, with his ballons-sondes, or sounding balloons, which

before him. His eyes closed, his head fell forward, and he dropped in a swoon to the floor of the car.

Tissandier and Crocé-Spinelli hauled him up, lent his head gently against the basket-side, and, suffering as they also were, spoke words of encouragement.

A few minutes later, Spinelli was overcome by the intense cold, and collapsed. Gaston Tissandier was now alone in the blue inverted bowl of the sky. There was absolute silence—silence such as is never known on earth—a silence against which the waft of falling leaf would be noise. It was the silence of the awful immensity of space.

Tissandier felt no upward movement, no wind, nothing.

He was just suspended in a deep, deep, blueness—floating as if in a dream.

But this cold, this gasping—and still he was rising.

How much longer before he too fell suddenly insensible?

He glanced at his barometer. No, the balloon had not yet reached its ceiling. On then to the end!

At 27,000 feet no further height was registered. That, then, was the end of the adventure, and it was as well, for Tissandier could scarcely

raise his arm to pull the valve-cord and release the gas.

As he descended, his breathing grew less laboured, his heart-beat less fiercely, a little warmth crept back to his frozen limbs. He looked at his companions, but no warmth had come into their cheeks; no warmth would ever come again into their cheeks. They were dead.

But the veil of the unknown had been drawn back yet a little farther.

Secret Places of the Heavens

Other explorers were pushing out in various directions. There was a little band engaged in investigating the mystery of clouds, how and when they formed, their heights, their temperature, their effect upon the surrounding air. Maybe in the country of clouds there were regions of intense cold, of soft warmth, of strange magnetic and electric influences. Through the vast valleys of cloudland, what fierce winds were sweeping, what new forces were at play?

One, Luke Howard, patiently observed, and eventually made a valuable classification of cloud forms.

M. Hermitte and others followed him, with his ballons-sondes, or sounding balloons, which

are miniature balloons fitted with thermometer, hygrometer, and barometer, and released at different places and various hours.

After many experiments, it was determined that, to a considerable height above the earth's surface, the temperature falls three degrees Fahrenheit for every thousand feet.

Two other adventurers, Rev. George Fisher and Sir Edward Parry, had, in 1822–3, visited the Arctic regions and probed into the hidden places of the air above those frozen wastes with self-recording thermometers.

Then there was Dr. A. Berson who, on 11th May, 1894, rising from Strassburg, reached a height of 31,500 feet, and found the temperature to be −54° F.; and on 15th September, 1898, Berson and Stanley Spencer, from the Crystal Palace, went to 27,000 feet; and on 31st July, 1901, Berson and R. J. Süring went up to 34,500 feet, but though they used oxygen as they entered these upper regions, one or the other was unconscious for periods during the last 3000 feet.

And now through all the years to what extent have those intrepid adventurers learned the secret of the unknown?

They discovered many secrets. They had tabulated hundreds of temperature readings and found a remarkable fact, namely, that above

a certain height, varying from 18 Km. above the Equator to 6 Km. or less at the Poles, the temperature remained constant with the increasing height. That is, above a curve falling away from the Equator to the Poles, temperature does not vary as you ascend.

To Teisserenc de Bort and Assmann, 1899–1902, belongs the credit of first stating this valuable fact. Then those new regions were named.

The region above the boundary curve AC (fig. 10) was named the Stratosphere, and the region below, the Troposphere, whilst the boundary layer represented by the curve AC is called the Tropopause, which over Europe lies at a height of roughly 10·5 Km.

Generally speaking, in the troposphere the temperature falls steadily with increasing altitude at a "lapse rate" of 3·3° F. per 1000 feet. Occasionally, however, regions of temperature inversion are met with where a layer of relatively warm air lies above a colder one.

Above the tropopause comes the stratosphere, extending to a height of about 31 Km., a vast, intensely cold void, with an average temperature of −60° F. With the possible exception of Glaisher, the first man to penetrate this strange region was Professor Piccard on the night of 27th May, 1931, when he and his

assistant, M. Kipfer, established a new height record of 53,000 feet.

So then, above the earth, the explorers found

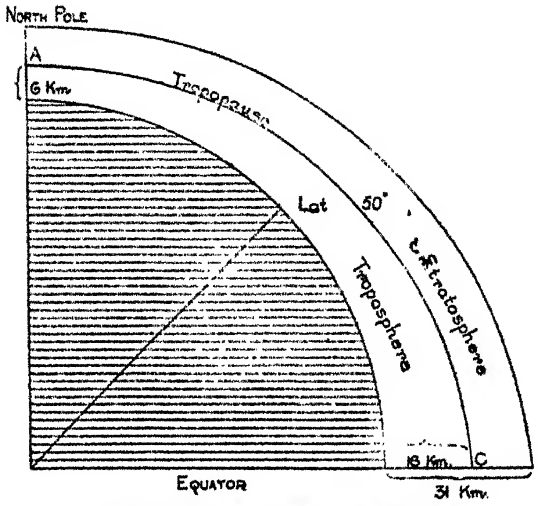


Fig. 10.—Troposphere and Stratosphere
(Air scale enormously exaggerated)

strata of air, each stratum possessing different characteristics. That was one thing. Another was that the air above 16,000 feet was so thin that it would scarcely support life, and the oxygen apparatus was needed.

The effects upon the body and mind at those

great altitudes were found to be: loss of judgment, drowsiness, breathlessness, a sense of overwhelming fatigue, a sapping of morale, with the consequent loss of fighting power, greatly quickened respiration and corresponding strain upon the heart, bleeding of the nose, and, as in the case of Glaisher, blindness.

They learnt that in the region of the troposphere the wind's speed increased as they ascended. They learnt that above the tropopause, that is, in the stratosphere, the force of the wind grows less, until there is almost perfect calm.

They found themselves, at great altitudes, floating in a sky of deep azure, and that a star now and again was visible in the broad light of day.

Beneath the clouds were air-pockets, and strange winds, and electric forces that sent the magnetic needle oscillating violently.

There are no clouds above six miles.

The earth appears but a dull grey mass beneath; all sound ceases above a certain height, and the light of the sun illuminates colours to a far greater intensity than on earth.

They found that at the height of Mont Blanc one half of the air would be below you, at 50,000 feet seven-eighths of the air, and at 65,000 feet no less than thirteen-fourteenths.

What is still beyond?

All this, then, has been discovered, but what else is yet to be revealed? The ever-questing mind of man is still unsatisfied, and will for ever be unsatisfied in this mysterious, miraculous universe. What is beyond that 53,000 feet reached by Professor Piccard?

Above the stratosphere is another region in which the temperature begins to rise again.

Not much is known about this third stratum. It is believed, however, that at a height of 25 miles the temperature of sea-level is reached once again, while at 40 miles a thermometer might record the boiling-point of water—212° F.

Such knowledge as we possess of this strange condition of affairs we owe in large measure to the flights of ballons-sondes.

The ballon-sonde is quite a small balloon, only a few feet in diameter, for carrying recording meteorological instruments. To enable it to reach great heights it is inflated with only just enough hydrogen to lift its load from the earth so that there may be ample room for expansion consequent on high altitudes. Hydrogen is used for balloons, in spite of its inflammability and high cost, because of its extreme lightness, which enables 1000 cubic feet of it to lift 71 lb.

The ballon-sonde will return to earth either on account of gradual leakage of gas or else because it has burst. In the latter case the fabric may well act as a parachute and bring the instruments to earth in safety. A notice on the equipment requests the finder to return it to the owner.

In this way a mass of useful information has been acquired in recent years.

In a still smaller form sounding balloons without instruments are very useful at commercial aerodromes in providing an indication of the direction and velocity of the wind at various altitudes. The balloons are all made of a standard size and filled with the same quantity of gas, and therefore have a fixed known rate of climb. By observing them with a theodolite at regular intervals of time, it is possible with the aid of a specially prepared slide-rule to determine rapidly the data already mentioned for broadcasting to pilots by wireless of imminent weather conditions.

To return to the conditions of the third stratum, it should be remembered that sound waves are produced in and propagated by air, and so where there is no air there can be no sound. Very tenuous air cannot transmit much sound. However, exploding meteors have been heard at an altitude of 27 miles, proving that

Enough has now been said to show that considerable changes in the plane are needed. Now let us consider the engine. It will be recalled that in the description of the Schneider-Rolls-Royce use was made of a supercharger or pump to assist the flow of the charge into the cylinders. The engine of the stratospheric plane will be required to work under conditions of great difficulty. At an altitude of 10 miles the height of the barometer is only $3\frac{1}{2}$ inches as compared with the normal 29–30 inches at sea-level. This means that the pressure tending to force the explosive mixture into the cylinders is only about $\frac{1}{8}$ of the normal value near the earth's surface. Again, even when the cylinders are full they will contain merely $\frac{1}{8}$ of the normal charge at sea-level. Such a charge clearly will only develop a very small power. Engines for these craft must employ superchargers. Indeed, it will probably be necessary to make use of three superchargers working in series, the output from the first feeding the second, and the output of the second supplying the third, which will drive the gases into the cylinders at a very high speed. Another difficulty in engine operation is the extremely low temperature, about −60° F., which may cause lubrication troubles, and necessitate special precautions to prevent the petrol freezing.

As far as the pilots are concerned, a sealed cabin will be required supplied with air at approximately normal atmospheric pressure and fitted with apparatus to maintain a practical working temperature. The construction of such a cabin entails a whole series of fresh problems How are the controls to be operated from the inside? How is the supply of fresh air to be maintained? What will be the best method of regulating the temperature? These and other problems must be met and solved before a really satisfactory stratospheric aeroplane is evolved.

To pilot the stratospheric aeroplane will not be a very pleasant task, nor one that would be entrusted to any but the most highly skilled.

Of what practical use is the evolution of such craft?

The answer is, that the essential advantage of air-travel over other modes of transport is speed, and that the low density of the high levels will greatly reduce head resistance, and so give the possibility of increased speed without the excessive power-to-weight ratio required by the S.6B.

It may be, then, that a speed of 1000 miles per hour will no longer exist merely in the imagination, and that shortly New York will be within four hours of London.

That would indeed be a proud achievement!

But apart from all such considerations, here is the arresting spectacle of man bracing himself to pierce the veil of the Great Unknown.

What further secrets of the Eternal will surrender to his unconquerable spirit?